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PLANT ANALYSIS AS AN APPLIED SCIENCE.

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MISS ABBOTT was introduced by Prof. Persifor Frazer, and spoke as follows:

SCHLEIDEN,[1] in his principles of botany, states: "Botany is an indispensable branch of knowledge for the chemist and physiologist." I think he might have said, with equal truth, chemistry and physiology are indispensable branches of knowledge to the botanist. An acquaintance with these three branches of knowledge is indispensable to the plant chemist. If we consider that our food, fabrics, dye stuffs, perfumes, drugs, and beverages, are all derived from plants, we can scarcely fail to inquire into the functions and intimate structure of vegetable life The application

[1] *Principles of Scientific Botany.* By Dr. J. M. Schleiden, London, 1849.

of chemical knowledge to the study of plant life under all conditions is the first steps towards a practical solution of the problems of agriculture, materia medica, and the industries derived from plant sources.

As long ago as 1795,[1] a learned Scotch nobleman said: "Indeed there is no operation or process, in agriculture, not merely mechanical that does not depend on chemistry." Fifteen years later, after Earl Dundonald's treatise, the first vegetable substance was accurately analyzed. Another period passed before the analyses of Liebig. Since that day investigators have been busily engaged in plant analysis.

Plant analysis to-day rests on a sure foundation as a distinct subdivision of general chemistry. Chemistry teaches us what vegetation needs for its growth, and points out the sources whence the materials for crops can be derived. Intense cultivation of the plant is the agricultural motto. The contrary is true for pharmacy. Plants which are to be used for medicinal purposes should grow under natural conditions. Cultivation of plants tends to diminish in quantity or to eradicate their noxious or medicinal principles. According to Prof. Vogel, hemlock does not yield coniine in Scotland, cinchona plants are nearly free from quinine when grown in hot houses, and tannin is also found in the greatest quantity in trees which have a direct supply of sunlight. Wild belladonna plants[2] contain more alkaloids than the cultivated.

Until within a comparatively very recent date, there were no schemes for vegetable analyses equivalent to *Fresenius's Manual for Inorganic Substances.* The irregularities of the methods of individual investigators in plant chemistry made it extremely difficult for students to follow this kind of analysis. The deficiency has been filled by the admirable book on *Plant Analysis*, by Prof. Dragendorff, of Dorpat, Russia. This book has appeared in a French translation,[3] and the first edition of an English transla-

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[1] *How Crops Grow.* By S. W. Johnson. London, 1869, p. 4.

[2] "The Alkaloidal Value of Cultivated and Wild Belladonna." By Girrard. *Pharm. Jour. and Trans.*, vol. xv, p. 153.

[3] *Encyclopédie Chimique.* Tome X. "Analyse chemique des Végétaux." Traduit de l'allemand et annoté. Par F. Schlagdenhauffen. Paris, 1885.

tion[1] was published a year before. Prof. Dragendorff does not claim to have written a perfect book. He offers a scheme, which, if followed, supplemented by well-known or original methods in the study of special or new compounds, will give the student a knowledge of the chemical constituents of a plant which he could not well obtain by a non-systematic scheme.

Dragendorff's scheme has been criticised as encouraging a mechanical method of work on the part of the analyst, but I think any student on working for the first time on a new drug by this method will find that he will be thrown very much on his own resources, and that the scheme serves him merely as a chain and anchor in a sea of novelty and uncertainty. It is indeed the most complete scheme for plant analysis which we have.

The scope of plant analysis is well outlined by Dragendorff in his introduction, and if my time permitted me, I could not do better than read it. The attention of the reader is directed to the great number of species of plants which occur in nature, to the great abundance and variety of their chemical constituents and to the circumstances that almost every skilful analysis of a plant that has not been examined yields new hitherto unknown products. The difficulties of plant analysis are pointed out, but it should be the effort of future investigators to endeavor to overcome these difficulties, when the importance of plant chemistry is considered in relation to scientific botany and chemistry, medicine, pharmacy, dietetics, agriculture, etc. This author says, that the analyses of plants in one respect possess an advantage over the analyses of minerals,[2] and in that respect can often be made more complete than that of a mineral.

It would not be possible within the space of an hour to give an accurate description of how to analyze a plant and the many methods which may be followed. I can give an idea of how to follow the scheme of which I have spoken as being the most complete, and the practical application of some facts derived from plant analysis.

The specimens which are presented for analysis should be in

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[1] *Plant Analysis.* By G. Dragendorff. Translated from the German by H. G. Greenish. London, 1884.

[2] *Plant Analysis.* English Translation, p. 2.

good condition and well selected as typical of the genus or species. In case of comparative studies the time of year of the gathering should be noted. All foreign substances and dust should be removed and care taken not to displace parts of the specimens.

All plants are chemically composed of two classes of substances and on incineration one class is decomposed into gases and the other class forms the ash constituents. These two divisions of the plant's constituents are known as the volatile and fixed parts. The manner of proceding with an analysis of a plant is somewhat different in the case of fresh plants and those which are air-dried. Fruits and succulent plants and fleshy roots may sometimes be examined with advantage in the fresh condition, especially if they contain much saccharine material or volatile products. Generally the parts of plants to be used for analyses are dried at a temperature under 30° C., or air-dried until in a state to powder; for all vegetable substances must be brought into fine subdivision before extraction, in order that the solvents may penetrate the cells.

The fine powdering of the material is of the utmost importance; a drug mill is usually used for this purpose. An agate or iron mortar may be used sometimes to advantage, or the material may be grated upon a fine grater, and then submitted to the same process of powdering and sifting, until it can be passed through a No. 80 sieve.

The Mexican ocotilla bark[1] is resinous and contains a wax, and it is very difficult to powder. From this fine powder the analysis yielded by cold maceration thirteen per cent. of waxy substance. Hot maceration gave nine per cent. An analysis from portions less finely powdered gave three per cent. less of wax. To estimate the amount of moisture retained in the air-dried plant, a small quantity of the powder from two to five grammes may be weighed and dried until constant weight at a temperature from 100° C. to 105° C. By means of this determination the results of all other estimations of the analysis can be calculated to the dry substance. Even in the case of fresh plants, it will be necessary for a quantitative examination of the entire plant at least to dry the portions which are to be treated with petroleum-ether, ether, and alcohol.

[1] "Preliminary Analysis of the Bark of *Fonquieria Splendens*." By Helen C. DeS. Abbott. *Proc. Amer. Ass. Adv. of Science*, vol. xxxiii. *American Journal of Pharmacy*, February, 1885

The powder, which has served for the moisture determination, is carefully burned at a dull red heat, and the ash residue weighed. This gives the total ash constituents of the plant. In many cases it is desirable to estimate the amount of soluble and insoluble ash, and to determine quantitatively one or more of the ash constituents, especially sulphuric and phosphoric acids and potash. In the ash may be found phosphorus, sulphur, silicon, chlorine, potassium, sodium, calcium, magnesium, iron, and manganese as well as oxygen, carbon, and nitrogen; rarely lithium, rubidium, iodine, bromine, fluorine, barium, copper, zinc, and titanium. The carbon, hydrogen, nitrogen, sulphur, and phosphorus are derived more especially from the organized parts of the plant, as the protoplasm and cell wall, and from carbonaceous substances, such as sugar, fats, and acids. It was stated that the volatile part of plants on incineration is gaseous, consisting principally of carbon-dioxide, watery vapor, and nitrogen. The inference being that the combustible portion of the plant contains the elements carbon, hydrogen, and nitrogen.

The fact that various mineral constituents are essential to the growth and development of plants is of practical value in agriculture. The soil must contain the various constituents in such quantity and form as to be available to the plant. The ash analysis of any plant indicates in a great measure the character of its surrounding soil, though the chemical composition in which the ash is contained in the plant is not necessarily the same as in the soil.

In investigating a new plant for the first time, all rational means for discovering its component parts should be resorted to. Before beginning the systematic analytical scheme, a micro-chemical investigation of thin sections of the plant, and even of the powdered plant may be followed. I have found it an excellent aid in the work, after knowing what constituents were present from chemical analysis, to determine in what tissues and cells these various substances are found. A drop of the extracts evaporated on a glass slide frequently indicates the character of the substances contained in them.

It is of importance to determine if volatile oils or acids, alkaloids and other substances are present, which can be separated by distillation, and for this purpose a sufficient quantity of the powdered plant may be mixed in a convenient vessel with water,

acidulated water, or milk of lime, and the mixture heated, preferably by steam. The distillate is condensed and may be examined as to its reaction, odor, and physical appearance. If the aqueous distillate is agitated with a light petroleum-ether[1], volatile products may be readily obtained.

Many volatile oils diffuse in moist air and pass off with the petroleum-ether, if precautions are not taken to prevent it, but a system by Osse[2] has been devised to evaporate the petroleum-ether and save the volatile oil.

Distillation of volatile principles may be sometimes substituted by other methods, such as "infusion" and "enfleurage," of which I shall speak later.

The following is the general plan I usually follow, based upon Dragendorff's scheme in order to determine the constituents of any plant. Twenty, fifty or 100 grammes of the dried powdered plant are weighed and macerated with successive solvents. The solvent is added in the proportion of ten c. c. to one gramme of powder. This is allowed to stand, with frequent shaking, for eight days, when the liquid is removed with a pipette or filtered from the powder. The residual powder is then rinsed with more of the solvent, which, added to the extract first obtained, is made to a known volume. The powder is dried at the ordinary temperature, and is then ready for maceration with a second solvent, and so on, until the sequence of solvents has removed all soluble matter from the powder. The residual insoluble portions are cellulose, lignin, and other allied substances, which form the firm frame work of the plant.

The solvents used must be chemically pure. The order of solvents recommended by Dragendorff, and the classes of compounds which may be extracted by them are given in the table.

PETROLEUM-ETHER EXTRACT.

Ethereal oils; volatile fat acids; glycerides; waxes; camphors; cholesterin or allied substances; chlorophyll and alkaloids with fixed oils; aldehydes; ethereal salts; alcohols; aromatic acids; resins.

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[1] Manufactured by Dr. H. W. Jayne, Frankford, Pa.

[2] *Archiv. d. Pharm.* (3), vii, 104 (1875). (*Year-Book Pharm.*, 1876, 362.)

ETHER EXTRACT.

Resins; waxes; fats; chlorophyll; coloring matters; organic acids; glucosides; alkaloids; (caoutchouc, chloroform, or bisulphide extracts).

ALCOHOL EXTRACT.

Tannic acids; bitter principles; organic acids; alkaloids; glucosides; glucose; saccharose; coloring matters; resins.

WATER EXTRACT.

Mucilaginous and albuminous substances; dextrin and other carbohydrates; saponin and allied compounds; glucoses; saccharoses; organic and mineral acids.

DILUTE SODA EXTRACT.

Metarabic acid; albuminous substances; phlobaphenes, etc.

DILUTE HYDROCHLORIC ACID EXTRACT.

Parabin; oxalate of calcium, etc.; starch.

DETERMINATION OF LIGNIN AND ALLIED SUBSTANCES AND OF CELLULOSE.

Benzole, chloroform, amyl alcohol, and acetic ether are frequently valuable solvents for certain extractions, although they are not included in the general scheme.

Dragendorff recommends the maceration to be conducted at the ordinary temperature, but a fixed oil, if present, may be extracted more readily by exhaustion at an elevated temperature. Such substances, as caoutchouc, may be readily extracted by boiling chloroform or bisulphide of carbon. If a known volume of the extract is evaporated, the residue will yield an approximate result of the amount of definite substances contained in the plant.

In my own work, I have usually found it convenient to take about twenty grammes of the powdered plant and exhaust them in a displacement apparatus. There are some advantages for this method in a preliminary study of the plant. The time necessary for the exhaustion is very much lessened; from ten to twelve hours at the most is ample time to allow the apparatus to run with each solvent, if the solvents are kept at a boiling heat during this period. It is a rapid way to determine qualitatively what constituents are to be found in any plant, and this may be followed by a careful

quantitative study on larger amounts. The general insight which can be obtained of the chemistry of a plant from this small quantity of material serves as a valuable guide for the future study on a larger scale.

The extracts obtained by heat show more proneness to oxidation than those from cold maceration, and there are some slight differences in the character of the extracts. The tendency of the higher temperature is to increase the number of constituents in the first extracts; *i. e.*, hot petroleum-ether will remove a considerable quantity of chlorophyll; hot ether will extract tannin, and hot alcohol extracts contain sugar, saponin, etc. After the hot alcoholic maceration; the water, dilute soda, and acid extractions are conducted at the ordinary temperature.

It will depend somewhat upon the object in view on the part of the analyst what course to follow in the study of a plant. If only one compound is to be isolated and examined disregarding the other constituents, suitable methods of study will be employed for this end. Even when Dragendorff's systematic scheme is followed, a fresh portion of powder should be extracted with water for an accurate estimation of soluble albuminoids, amides, and other classes of nitrogenous compounds. These subjects are very clearly stated in the volume of *Plant Analysis*, to which I have referred.

I wish to bring forward some well-known statements, which may serve to illustrate the practical application of facts discovered by plant analysis. One of the more recent applications of new processes to industrial chemistry is the manufacture of hop-resin extract [1] on a large scale. The use which is made of this extract, is in the manufacture of beers, and it is being used to a large extent in Philadelphia and New York, fully supplying the place of the ordinary hop. The process is somewhat as follows: The hops are loosely placed in large wire cages, and then are run into an immense boiler or "extractor." A heavy door is shut securely, and about 300 barrels of light petroleum are pumped in by an engine, and heat is applied by means of a steam coil, until a pressure of 100 pounds to the square inch has been obtained.

The object of this high pressure is to break or crush the glands, called lupulin, which contain the valuable principle, this being

[1] "Hop Extract." By W. B. Bissell. *Am. Jour. Pharm.*, April, 1885, p. 166.

taken up by the hot petroleum. The process is so managed that there is very little waste of menstruum, and the hop extract is readily separated; the petroleum-ether being used over and over again. One pound of this extract represents about twelve pounds of choice hops, and it has a great advantage over the hop itself, as it will keep for an indefinite time; whereas at the end of two years the hop is useless.

Hop-resin,[1] or bitter, was discovered from the chemical analysis of a plant, and it illustrates to what practical ends a fact derived from this source may be applied. The solubility of hop-resin in petroleum-ether is availed of also in the examination of beer.[2]

Vegetable wax is found on the surfaces of leaves, on the stem, and the berries of plants, and is obtained from many sources. The commercial supply comes from certain species of the palm tree family in considerable quantities. Carnauba wax is from a large Brazilian palm. *Myrica*, or myrtle, wax comes from the berries of an American and Mexican plant, *Myrica cerifera* of the *Myricaceæ* family, and Japan wax is obtained from *Rhus succedaneum*.

Vegetable wax[3] is principally used in the manufacture of candles, but on account of its greater dryness, it breaks much more readily than animal wax; hence, if animal wax is mixed in small proportions with vegetable wax, it answers very well. It is also used in adulteration of beeswax. Cerosin,[4] a wax from sugar cane is said to melt at 82° C. It has been proposed, on account of its high melting point, to use it in the manufacture of candles. Five hundred plants can furnish, it is claimed, one kilogramme of wax.

The bark of *Fonquieria splendens*,[5] or the ocotilla tree of

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[1] Lermer, *Vierteljahresschr. f. prakt. Pharm.*, xii, 504, 1863; Bissell, *Amer. Jour. Pharm.*, xlix, 582, 1877; Griessmayer, *Ber. d. d. Chem. Ges.*, xi, 292, 1878; Isleib, *Archiv. d. Pharm.* (3), xvi, 345, 1880; Cech., *Zeitschr. f. Anal. Chem.*, xx, 180, 1881.

[2] Griessmayer.

[3] *Matières Premières Organiques.* Par Pennetier, p. 771.

[4] *Matières Premières Organiques.* Par Pennetier, p. 771. *Annales de Chimie et de Physique*, lxxv, 218. *Annal d. Chem. und Pharm.*, xxxvii, 170, 1841. *Ibid* (new series), xiii, 451.

[5] *Proc. A. A. A. S.*, vol. xxxiii. *Amer. Jour. Phar.*, Feb., 1885. The analysis of this plant is among the first published accounts of plants treated by Dragendorff's scheme in this country.

Mexico, also yields a wax. The native Indians use this stem for illuminating purposes; it burns with a red, smoky, flame, and is called the candle tree.

The vegetable waxes are mixtures of resinous substances and the higher fatty acids, and differ from the fixed oils in containing in place of glycerin, cetyl, ceretyl, and myricyl alcohols; properly they contain ethers of higher alcohols of the ethylic series and free acids. The wax obtained from the *Gramineæ* or grasses, to which class sugar cane belongs, has been studied by König;[1] he found that it contained no glycerine but chloresterin, cerotic, palmitic, and oleic acids.

The importation of vegetable and mineral wax[2] for 1884, 617,992 pounds ($69,026); 1885, 1,056,438 pounds ($1,123,976).

The oils of vegetable origin used in commerce[3] are usually derived from grains; a few only are extracted from the fleshy parts of fruits. The oil is found in the form of minute drops in the rinds of fruits; the orange contains four different oils, and in many seeds the absence of starch is replaced by oil, and serves the future seedling for nutrition. The oil is usually obtained on a large scale by pressure, however oils are soluble in petroleum-ether, and may be extracted by it. In France,[4] the cultivation of oil-yielding plants occupied 445,000 hectares, the product of which amounted to 105,000,000 francs. Olive oil[5] is obtained from several species of the olive tree. It serves for many purposes, and enters into the food of some nations. In Spain, a kind of soup, made of oil, garlic and bread soaked in water, is eaten by the poorer classes.

The nuts[6] of *Carylus avellana* give an excellent table oil; it is also used in perfumery. The residue from the extract is used for almond confection, and is preferable to that made of ordinary almonds. A commerce is made in China of "Chou-lah[7]" obtained from one of the *Euphorbiaceæ*. This tallow is made into candles,

[1] *Landw. Versuchsstat*, xiii, 241.

[2] Bureau of Statistics, Treasury Department, 1885.

[3] *Loc. cit.* Pennetier, p. 706.

[4] *Ibid*, p. 709.

[5] Pennetier, p. 709.

[6] Pennetier, p. 750.

[7] *Ibid*, p. 752.

which burn with a brilliant and white flame. There is an enormous demand for them. Many other plants of the same family furnish this oil. The genus *Bassia*, of the *Sapotaceæ* family, yield several important fats, among which is one known as Galam butter. This vegetable butter can replace animal fats, and is largely used in soap making. The annual report of the manufacturers of linseed oil alone for one year was figured at high rates, but the manufacture and uses of this oil are too well known to need more than a mention.

Olive oil in the *American Pharmacopœia* is replaced by cotton-seed oil.[1]

The supply of cotton seed—*Gossypium*—is obtained from several countries, and may be said to be inexhaustible. The Southern States of North America contribute the largest quantity by millions of tons, a large proportion is not worth the expense of transit, and is burned for fuel and given to stock for litter. A considerable quantity is used in the manufacture of decorticated cotton cake and oil. Egypt is said to grow a superior quality of seed, and England derives her principal supply from there. Improvements in the method of irrigation are said to have increased the annual quantity, but the average of past years has been about 250,000 tons.

The seeds yield some twelve to twenty per cent. of oil. The oil in appearance, taste, and smell resembles fresh olive oil.

The fixed oils are chemically glycerides and are principally composed of glycerin, in combination with oleic, palmitic, and stearic acids. They are frequently solid at ordinary temperature, and their consistency depends upon the proportion of oleic acid present.

Commercial oils[2] frequently contain free acids, thus in palm oil the free acid calculated as palmitic acid usually varies from twelve to eighty per cent. The presence of free acid in an oil is doubtless the principal if not the only cause of its tendency to act on metals, and therefore seriously affects the suitability of an oil for use as a lubricant.

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[1] "Notes on Cotton-Seed Oil." By W. Gilmour. *Am. Jour. Pharm.*, Nov., 1885, p. 565.

[2] *Commercial Organic Analysis.* By A. H. Allen. Phila., 1887. Vol. ii, p. 28

Before leaving the subject of vegetable oils, I wish to call attention to the essential oil industry in Grasse.[1] The world-wide fame of this locality depends upon the essential oils of plants which grow wild or are cultivated in the neighborhood, The oil of lavender, rosemary, the garden thyme, of the *Labiatæ* family afford an important export industry of Grasse.

The following quantities of oil are delivered in Grasse every year: From the lavender, 80,000 to 100,000 kilogrammes; from thyme, 40,000, and from rosemary, 20,000 to 25,000 kilogrammes. The quantity sent out from Grasse probably meets the requirements of the whole world. Dalmatia only furnished the oil of rosemary and sends about 20,000 kilos of this essential oil into the market; Grasse also sends forth each year oil from the citrus species, especially oil of neroli which is much esteemed. Orris butter is distinguished above many other perfumes by an agreeable softness and great permanence. One of the houses in Grasse prepares four to ten kilogrammes yearly. Its value in Grasse is 1,500 to 1,800 francs the kilo. Besides the wholesale distillation of orange flowers and roses, some other aromatic plants are occasionally worked up when needed, though not to any great extent.

The processes used for extracting these perfumes by the methods of "infusion" and "enfleurage" are extremely interesting and may deserve a passing notice. The fat used as the basis of the "pommade" is selected from the best pig's lard or beef suet. The melting, its mechanical purification, and washing are conducted with great care. The stability of the fat is increased by its digestion with benzoin. The "infusion" is effected in large jacketted boilers, in which the fat is warmed by steam heat and the flowers are added. In the month of May over 10,000 kilos of rose or bigarade flowers pass daily for many successive days into the boilers of the factory of one house alone. The fat is diligently stirred by female workers, the expression by means of hydraulic presses is done by men. After the clearing of the fat, the finished "pommade" is at once weighed and stored in tin boxes.

In the case of the more delicate perfumes, the above method of "infusion à chaud" is replaced by "enfleurage." For this purpose light square wooden frames, about eighteen inches each way, in which a plate of glass can be placed, are used. Upon each glass

[1] F. A. Fluckiger, *Amer. Jour. Phar.*, March, 1886, p. 137.

is spread a quantity of fat in a thin layer, and this is strewn thickly with flowers. Sometimes contact with the fat is avoided, and the layer of fat is confined to the other glass wall of each compartment. When a perfumed oil is desired, cloths saturated with oil for the "enfleurage" may be used. The flowers are shut up in these glass compartments for a longer or shorter time, and are repeatedly renewed and replaced by fresh ones. The perfumed fat is mixed with alcohol by means of powerful stirrers. The alcohol takes up scarcely any of the fat, but the greater part of the odorous substances.

From several trials, I think, these processes of extraction may be applied to extract the delicate odors of barks, and other substances which would be destroyed by distillation, and have escaped detection up to this time.

Among the chemical substances recently introduced into the field of chemical industry[1] may be mentioned cholesterin, or lanolin, $C_{26}\ H_{44}\ O + H_2\ O$. Commercially, this substance is obtained from animal sources; but its wide distribution through the vegetable kingdom warrants its mention in this place. The singular property of this substance and its promising commercial future deserve more than a passing notice. Liebrich observed that cholesterin fat possesses the peculiar property of being able to absorb more than 100 per cent. of water, and this singular property was denominated by the great pharmacologist, lanosation, while the cholesterin, mixed with water, was termed by him, lanolin. He also first called attention to the great therapeutical value of lanolin, and shortly afterwards the industrial production of pure lanolin was commenced by a Berlin firm,[2] and its manufacture has been of late steadily increasing.

Lanolin is already taking the place of vaseline, paraffine, and lard. Its efficacy has already been established beyond doubt, and its superiority is due to the extraordinary readiness with which it is absorbed by the skin. This property is not known to belong in a similar degree to any other fatty substance. Besides the medicinal use it has also been already introduced into various branches

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[1] "Notes on Chem. Substances recently introduced into the Field of Chem. Industry." By J. Levinstein. *Jour. Soc. Chem. Industry*, Nov. 29, 1886.

[2] Messrs. Jaffé & Darmstadter.

of industry, such as perfumery, soaps, and pomades, also for greasing leather belting and for improving the pliability of leather.

The history of the wholesale drug trade for the year 1886 is one of the most remarkable on record since 1879–80. In a late number of the *Druggist's Circular*,[1] a summary is given of the year, from which I have taken some statements.

From the table of prices, as follows:

	January 1st.	*December 15th.*	*July 1st.*
Alcohol,	$2 10	$2 17	$2 09
Camphor,	23	22 25	23
Gum arabic,	70	95	82½
Morphine,	2 25	2 10	1 90
Vanilla bean,	10 00	18 00	12 00
Copaiba balsam,	34	36	34
Cubebs,	90	1 35	95
Tragacanth,	45	42	37½
Senna leaves,	15	27½	30
Golden seal,	14	18	13
Pink root,	35	47½	60

The advance in alcohol is said to be the result of a combination amongst the distillers. Balsam copaiba has for a long time been very scarce; but the arrival of new stocks will make it freer. "Cubebs, vanilla beans, gum arabic, tragacanth, senna, golden seal, serpentaria and pink root have been and are still very scarce and are likely to be higher." * * * "The largest movement in cocoa leaves ever known, took place early in the month." * * * "A short crop of senna coming at a time when all markets were poorly supplied and during an unusual active period, is responsible for the upward movement of the drug." * * * "The position of quinine just now is an interesting one, and the future of the market depends upon the source of barks, and that at present is expected to be upward, owing to reduced visible and prospective supplies."

The commercial value of these drugs depend upon certain chemical compounds which they contain. The scarcity of some of these drugs in itself is a sufficient inducement to push forward investigation in plant chemistry, and to endeavor to discover the same valuable constituents or their equivalent in new plants.

[1] *The Druggist's Circular and Chem. Gazette*, Jan., 1887.

The preparation of fine prescriptions has been advanced by the perfection in chemical methods of isolating plant constituents. The medicinal value of many drugs is due to one or more principles, and to be able to administer these principles apart from the accompanying compounds of the plant is a triumph of analytical skill.

A new and convenient form to prescribe the more important alkaloids, glucosides, and other active plant principles, is offered by Frederick Stearns & Co., Detroit, Mich. This firm manufactures alkametric granules and alkadermic pellets. These granules contain carefully prepared medicines representing the pure alkaloid or active principle.

The enormous quantity of drugs used to furnish alkaloids or other medicinal principles may be seen from the import[1] of cinchona bark or other barks used in the manufacture of quinine:

	Pounds.	*Value.*
1884,	2,588,307	$718,035
1885,	3,559,691	913,189

Of sulphate of quinia:

	Ounces.	*Value.*
1884,	1,263,732	$1,610,163
1885,	1,390,126	1,292,794

Other salts of quinia:

	Ounces.	*Value.*
1884,	712	$1,038
1885,	5,435	1,868

Cinchonidia:

	Ounces.	*Value.*
1884,	381,885	$206,405
1885,	478,747	220,846

A new York firm[2] has recently introduced upon the market quint-essential oils; the odorous principle of these oils is due to the stearoptens or camphors, which readily separate from the more volatile portions.

It has been suggested, owing to the scarcity of gum arabic to introduce upon the market a gum[3] from a Mexican tree, called

[1] Bureau of Statistics, Treas. Dept.

[2] Fritzsche Brothers.

[3] "Products of the Mesquite." By H. J. Schuchard. *Amer. Jour. Pharm.*, Nov., 1885, p. 542.

the mesquite. This gum exudes from the stem and branches during the summer months. The analysis of this gum offers several interesting features, amongst others its solutions can be combined with basic lead acetate and ferric salts without being precipitated, and it is suggested for this reason the more applicable in medicine than in gum arabic. It is probable that in time gum mesquite will become a commercial article of importance.

We are indebted to plants for our tea, coffee, and chocolate supply, and these articles may be reckoned among our foods; for one or all are used by every people.

In Spain, chocolate is looked upon as a necessity. The Spaniard may be seen making his early breakfast with a slice of bread spread with a thick paste of chocolate. The smiling-faced "El cocinero" told me how he prepared it, by carefully melting the solid chocolate cake to the desired consistency. A cup of steaming hot goat's milk is offered to the traveller to mix with this chocolate if he is unable to take it straight.

"When Cortez and the Spaniards entered the vast Empire of Montezuma, they found the use of cocoa or chocolate as a beverage common. The Emperor alone drank it flavored with vanilla from a golden cup."[1] The Spaniards very jealously guarded as a secret the mode of chocolate manufacture, and were able to retain the monopoly of the trade for many years.

Theobromine, caffeine, and theine are the alkaloids which give cocoa, coffee, and tea their exhilarating properties. They owe their aroma to certain volatile oil, which in the case of cocoa is probably developed by roasting.

Tea[2] is of the utmost importance as an article of consumption, and far exceeds in demand cocoa or coffee. Tea can be grown in a wide range of climate; in Pekin with winters of Russian severity to Canton and Macao. Any country having a long and hot summer and a cold winter can grow tea. The proportion per head of consumption for Great Britain and Ireland during 1875 was 4·44 pounds.

The very best workers in gathering the tea leaves rarely earn as much as six pence a day, and until other nations can raise tea

[1] *Tropical Agriculture.* By P. L. Simmonds. London, 1877, p. 2.

[2] *Ibid*, p. 79.

for six cents a pound, they cannot compete with China in its production.

Guarana, a product allied to cocoa; maté, or Paraguay tea are also used. The same or allied alkaloids prevail in all the principal substances employed for these beverages in different parts of the world. After tea, there is scarcely any other staple of commerce used for dietetic beverages more generally acceptable with all classes than coffee.

The statistics of cocoa, tea, and coffee.[1]

IMPORTED INTO THE UNITED STATES.

Tea:

	Pounds.	*Value.*
1884,	65,774,234	$13,504,798 56
1885,	69,820,172	13,725,380 75

Coffee:

	Pounds.	*Value.*
1884,	532,514,850	$49,685,689 30
1885,	572,222,841	46,723,290 16

Leaves and shells of crude cocoa:

	Pounds.	*Value.*
1884,	12,263,948	$1,673,088 00
1885,	10,300,078	1,332,375 00

The above facts, including the tables of statistics, show the extent of our dependence on the presence of chemical compounds in the various plant sources, from which we derive many of our supplies.

The consideration of the cereal products of the United States and our domestic sugar supply in relation to this subject, seems of sufficient importance to detain us for a few minutes.

"The total production[2] of the six principal cereal grains of the United States, for the census year, amounts to 2,697,962,456 bushels, an average of 58·8 bushels per head for the whole population. The total breadth of cultivation and the amount of product of each of the grains is as follows:

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[1] Bureau of Statistics, Treasury Department.

[2] *Report on the Cereal Production of the United States*, Dept. of the Interior, Census Office, 1884, p. 381.

Grain.	*Acres.*	*Production—Bushels.*
Corn,	62,368,869	1,754,861,535
Wheat,	35,430,052	459,479,505
Oats,	16,144,593	407,858,999
Barley,	1,997,717	44,113,495
Rye,	1,842,303	19,831,595
Buckwheat,	848,389	11,817,327
Total,	118,631,923	2,697,962,456

"Whether considered in respect to breadth of cultivation, total product, or average production per head of the whole population, these figures place the United States at the head of the grain-producing countries of the world." * * * "The tables of cereal production, taken in connection with the tables of other production, and these compared with the returns of previous census years, show that agriculture continues to be the leading productive industry of the country, and cereal production the most prominent feature of this industry. * * *

"The increase in grain production, since the previous census enumeration, is in part due to the cultivation of new lands in the West and in the Northwest, but more largely due to gain in farming regions already occupied in 1870. The popular belief that the chief increase in production and the rapid growth of the grain exports is due to the cropping of new and cheap lands, is not sustained by the census enumeration. The tables of production show that the most of the grain is in regions some time in cultivation and on lands ranging in value from $30 per acre upwards. * * *

"The actual production of 58·8 bushels per head of total population shows that the United States must be a grain-exporting country, notwithstanding the enormously large consumption by its population. The grain and flour exports[1] for the five years ending June 30, 1880, amount as follows:

Grain.	*Bushels.*
Wheat and corn,	833,692,207
Flour and corn meal,	24,850,316
Total value,	$892,788,117

"The profitable cultivation[2] of cereals on a large scale is more dependent upon climate than upon soil. Rocks of various geo-

[1] *Cereal Report*, p. 383.

[2] *Ibid*, p. 396.

logical ages underlie the different portions of the chief grain-producing regions. The immediate influence of the underlying rocks is, however, greater in the Southern and Western portions of the United States than in the Northern and Eastern." The production and distribution of grain in the United States is influenced largely by the physical character of the soil. "The portions producing the bulk of the grain have soils of reasonable fertility, but are also those which are easily tilled, and upon which the best machinery and labor-saving appliances can be most readily used."

"The acreage and crop[1] of wheat, in 1879, amounted to 35,430,-052 acres, 459,579,505 bushels, the acreage being 29·7 per cent. of all the land and cereals, and the product about 9·2 bushels per head of total population. * * * *

"There is but little wheat land east of the Hudson River, and although New York and Pennsylvania produce considerable wheat, the great bulk of the wheat country lies West of those states, beyond the seventy-seventh meridian and the Appalachian Chain of Mountains, and north of the Ohio River. * * * *

"The successful cultivation of wheat, in a commercial sense, is determined by a complicated set of conditions." In an agricultural sense, "the yield and quality of the crop practically depend upon but five conditions: The climate, the soil, the variety cultivated, the mode of cultivation, and the liability to destruction by insects." Chemistry has to do, however, with only the soil and the variety of grain related. The chemical composition of the grain and its value as a bread plant not only vary greatly in the different varieties, but also in the same variety from year to year, and on different soils.

Indian corn[2] stands first in amount of the cereal productions of the country. This cereal is more generally distributed over the country than any other; the place of its greatest production is on the fertile prairies and river bottoms of the West, and north of the thirty-sixth parallel of latitude. A comparatively few states[3] produce the bulk of the crop, the four states of Illinois, Iowa, Missouri, and Indiana producing upward of fifty-two per cent.

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[1] *Cereal Report*, p. 440–442.

[2] *Ibid*, p. 470.

[3] *Ibid*, p. 471.

"The chemical composition[1] of Indian corn varies more than wheat, as might be expected from the vast number and great difference of its varieties. As a whole, it is not quite so rich in albuminoids." It varies also much more in the amount of fibre. The average proportion of starch is less than in wheat, but the most noticeable difference is in the amount of oil. Indian corn, when in the "milk," is a most nutritious and excellent food "The chemical analysis of green corn shows respectively fourteen to fifteen per cent. albuminoids, * * * * an amount equal to that in the very best wheat flour."[2]

Oats[3] stand the third cereal of importance in the United States. Maine, Vermont, New York, and Wyoming raise more oats than any other cereal. The muscle-producing value of oats depends upon the amount of their albuminoids. The average composition of some American oats for analysis showed a higher percentage of albuminoids than the richest wheat flours. The amount of fat in oats ranges from four to nearly six per cent.

Barley[4] is successfully cultivated in a wider range of climate than any other cereal. It is the most hardy of all the cereals, and it grows in the north nearly to the point where all cultivation ceases. On the other hand, barley flourishes well in semi-tropical countries, and in this country the state of its greatest production is South. In Arizona and Nevada, more of barley than any other cereal was grown in the census year.

Rye[5] has become of very minor importance in the United States, in comparison with other cereals. It can be grown upon very poor soils. In Europe, for many ages, it was the principal bread-stuff of the people, for it could be cultivated on soils too poor to grow wheat. Pennsylvania has, at each census return, been the leading state in total production, now followed by New York.

From analyses, rye in the kernel is less nutritious than wheat, and the deficiencies in their respective flours is still greater. Wheat flours average about eleven per cent. of albuminoids, while

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[1] *Cereal Report*, p. 482.

[2] *Ibid*, p. 484.

[3] *Ibid*, p. 491.

[4] *Ibid*, p. 497.

[5] *Ibid*, p. 502.

rye flours average at about six per cent. On the other hand, rye bran is richer in albuminoids than wheat bran.

The popular belief that buckwheat[1] is less strengthening and more fattening than wheat, is founded on a chemical reason; for the percentage of albuminoids is low, ranging from four to eight per cent. The starch is in larger amount than in wheat, the percentage of oil being about the same. The peculiar aroma of buckwheat cakes is probably derived from the presence of an essential oil decomposed by heat.

Chemistry plays an important part in the cereal production of our country. The United States Agricultural Department furnishes several reports on this subject.[2] The analyses have been conducted to show the effect of evironment on the grain. The albuminoids, fats, and ash composition of American grain are given and compared with foreign crops, and the average composition of flour from different sections of the country has been studied.

The importance of chemical analyses in this connection is evident, for the relative chemical composition of a cereal decides its nutritive value, and this information is essential to the farmer in the selection of the kinds of grain for sowing. The percentage of chemical composition of grains varies from crops grown in different sections of the country, and furnish a scientific basis for careful selection of climate and soil.

Agricultural chemical analysis is usually conducted to show the aggregate percentages of groups of substances. All the nitrogenous compounds are determined together and classed as the albuminoids; starch, gum, sugar, and similar substances, as carbohydrates. Oils, waxes, and allied compounds are classed as fats. Special compounds existing in minute quantities, but belonging to one of these classes, would fail to be detected in such a general plan of analysis; such compounds might have great economic interest. Careful and detailed plant analysis can be the only means to discover and isolate these principles.

The source of sugar supply to the world are from a few plants; the beet, maple, sugar cane, and sorghum. In our country during

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[1] *Cereal Report*, p. 508.

[2] *Buls.*, No. 1, No. 4, No. 9, Chem. Div. Dept. of Agr. By Clifford Richardson.

1883-84 beet-sugar was all made at Alvarado[1], Cal. Sugar manufactured from the beet on the Pacific Coast is an assured success. The climate and soil of Northern California, Oregon and Washington Territory are especially suitable to this plant. A vast range of territory in our Northern States would be adapted for the cultivation of the sugar beet. The causes of past failures to establish a beet sugar industry may be remedied, depending upon more scientific methods of agriculture and chemical methods. Maple sugar is costly, the trees yielding this product are of slow growth, and their territory of cultivation limited. An adequate supply cannot be expected from this source, nor from the sugar cane of the South during the present stage of this industry.

If it is admitted that the prosperity of a country is shown by its advance in agriculture, then the onward march should be encouraged by every means in our power. We should look to our own acres for our sugar supply, since this can become practicable, and not abroad. The encouragement of a sugar industry in this country is of importance, when it is considered that over $100,000,000 is sent out of the country for raw sugar annually.

The problem of how to reduce our revenue does not apply to this industry, and in a recent letter on a plan of tariff revision, Mr. E. H. Ammidown says: "Legislation to reduce the duty on sugar should be deferred until the conditions and prospects of the whole sugar industry have been more carefully investigated and are better understood. An industry which, if established, would produce $150,000,000 in value of a staple article of food required in every American household, and save $100,000,000 now or in the immediate future, annually paid to foreign producers, such an industry, with the example of France and Germany to encourage us, is of too serious importance to this nation to be treated by the national legislature otherwise than with the utmost caution and most cautious deliberation."

The following statistics will show the sugar and molasses importation:

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[1] "Our Sugar Supply." By H. W. Wiley. From *Bul.*, No. 2, Chem. Soc. of Washington. Jan., 1887.

For the year ending June 30, 1886,[1] free of duty from Sandwich Islands:

	Amount.	*Value.*
Molasses,	61,171 gallons.	$7,786 00
Sugar,	191,623,175 pounds.	9,166,826 00
Total,		$9,174,612 00
Dutiable.	*Amount.*	*Value.*
Molasses,	39,018,637 gallons.	$5,587,884 00
Sugar,	2,498,258,590 pounds.	71,606,918 00
Sugar candy, etc.,		23,333 00
Total,		$77,218,135 00
Value of all imported sugars and molasses,		$86,392,747 00
The value of all imported sugar and molasses, for the year ending June 30, 1885,		76,738,719 00
For the year ending June 30, 1884,		103,884,275 00
The total value[2] of domestic sugars and molasses amounted to		43,037,409 03
The amount of money sent out of the country during the last year to meet the demands of sugar consumption was		135,000,000 00[3]

The above figures show the amount of sugar and molasses consumed in the United States annually. If we are to obtain all of these products from our own lands, it is a reasonable question to ask, how is this to be accomplished?

Former analyses show that the yield of sugar from Louisiana cane is less than from cane grown in the tropics. The future prosperity of Louisiana growers need not suffer from this poorer juice. The recent experiments at Fort Scott[4] demonstrated that a given weight of cane, without notably increasing the cost of manufacture, yielded thirty per cent. more sugar than had ever been made before. The Southern sugar industry will thrive, with the encouragement of a greater sugar yield, and by the introduction of more scientific methods of growing and manufacture.

Of late years the manufacture of sugar from *Sorghum saccharatum* has attracted attention. So far, as a business project, it has proved a financial failure. From the recent chemical reports of the

[1] Bureau of Statistics, Treas. Dept. 1886.

[2] *Bul.*, No. 5, Chem. Div. Dept. of Agr., pp. 7 and 8.

[3] From. *Bul.*, No. 2, Chem. Soc. of Washington, p. 16.

[4] *Bul.*, No. 14, Chem. Div. Dept. of Agr., 1886. H. W. Wiley, Chemist.

Agricultural Bureau, under proper conditions of cultivation, this cereal promises to become a profitable source of sugar supply.

I give a few of the chemical results of the late Fort Scott experiments.[1] Up to October 1st, the mean composition of the chips entering the diffusion battery was:

	Per Cent.
Sucrose,	8·76
Glucose,	3·28
Soluble solids,	14·88
Available sugar,	2·64

Following that date:

	Per Cent.
Sucrose,	7·02
Glucose,	4·16
Soluble solids,	14·89
Available sugar minus,	0·85

With such raw material it was found to be impossible to successfully manufacture sugar.

It must not be inferred from these discouraging analyses that sorghum is not capable of becoming a good sugar-producing plant. Many samples of cane brought fresh from the fields or from protected parts of piles of cane cut for a day, showed a remarkably high percentage of sugar.

On September 30th, a sample of cane from the carrier showed:

	Per Cent.
Sucrose,	12·39
Glucose,	3·76
Total solids,	17·8
Available sugar,	6·98

Such cane would yield 140 pounds of sugar per ton.

An October cane cut one day gave an average of 176·6 pounds of sugar per ton.

Dozens of samples of cane during the season would have given over 100 pounds of sugar per ton. When it is remembered that sorghum cane can be grown and delivered at the factory for $2 a ton, the importance of these figures cannot be over-estimated. If sorghum can be produced which will contain five per cent. available sugar from the whole crop, the future of the industry is a most promising one.

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[1] *Bul.*, No. 14.

Until the variations of the percentage of sucrose in the juice can be controlled, sorghum cannot be considered a profitable crop for sugar production.

It is purely a question of more scientific agriculture. So far as the processes are concerned, the problem of extracting the sugar from the cane has been solved.

To insure the financial success it will be important to select a suitable situation of climate and soil. Before embarking upon a large money outlay, the scientific representative of a company should experimentally grow, under trial conditions, sorghum cane in the localities where it is proposed to start the industry.

On a broad scale the northern and southern limits have been already defined. Seventy degrees Fahrenheit is the isotherm[1] for the best sorghum sugar production for June, July, and August; but cane for syrup will grow north of that line.

At a comparatively small expenditure the question of climate for special localities and other conditions could be tested by a chemical analysis of the plant, whose juices respond as quickly to favorable or adverse conditions as the mercury to heat and cold.

Dr. Wiley[2] recently, in his annual address as President of the Washington Chemical Society, said: "The hope of sorghum is not in new methods and new machinery, it is in the skill and patience of the agronomist. Wise selection of seed, intensive culture, judicious fertilization—these are the factors that can make the sorghum sufficiently saccharifacient."

It seems to me that the refinements of plant analysis are destined to play an important part in this connection. Chemical analysis of chosen seed would ensure a wise selection for planting. Analysis of the cane and juice would show the results of experimental culture. For experiment, the proportional constituents of the soil may be varied, to determine if the proportion of chemical constituents of the cane, detrimental or favorable to the production of richer juice, may be controlled.

Analyses would show what external chemical conditions are requisite to insure a vigorous growth, and if upon these depends a larger sugar yield. Series of experiments at different stages of

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[1] *Bul.*, No. 3, Chem. Div. Dept. of Agr.

[2] "Our Sugar Supply."

growth undertaken to discover the chemical processes attending growth, maturing, and ripening of the canes under trial conditions are necessary to be known by the chemical representative of the producer.

Plant chemistry in applying this knowledge to practical agricultural ends will fulfil a high aim. It may be suggested as a worthy object of agricultural experiment to discover what parts of the residual sorghum, juice and cane after the sugar extraction may serve a practical end. A profitable utilization of these products would assist the improved machinery and new chemical processes in lessening the cost of sugar production. Paper[1] has been manufactured from the cellulose of the sorghum cane. Future experiments will determine the separation and economic interest of other constituents.

Very many dye substances of vegetable origin are used industrially. It would detain us too long to enumerate the list, and I shall select a few of the well-known ones for illustration:

The dye-woods imported in a crude state are as follows:[2]

Camwood:

	Tons.	*Value.*
1884,	659·82	$65,461 00
1885,	730·	68,721 00

Fustic:

	Tons.	*Value.*
1884,	11,811·	$177,830 00
1885,	8,090·	119,689 00

Logwood:

	Tons.	*Value.*
1884,	55,921·59	$875,291 00
1885,	56,507·80	904,205 25

The madder plant was formerly grown to a large extent in many countries, and in France[3] large tracts of land were given up to its cultivation. "Madder[4] owes its importance to the beauty

[1] "Sorghum Saccharatum." By C. A. Goessmann. From *Trans. N. Y. State Agr. Soc.*, 1861. *Bul.*, xli, N. J. Agr. Experimental Station, 1887, p. 23. *Bul.*, No. 14, Chem. Div. Dept. of Agr., p. 56.

[2] Bureau of Statistics, Treas. Dept. 1885.

[3] *Tropical Agriculture.* By P. L. Simmonds. London, 1877, p. 369.

[4] *Hand-Book of Dyeing and Calico Printing.* By W. Crookes. London, 1874, p. 228.

and fastness of the tints it yields, and to the fact that by a variation of the mordants used, it produces rose pink, black, violet, lilac, and puce colors." The character of the soil where the madder grows affects the color of the dye. The roots grown in a rich clay soil exhibit a rose pink color; under other conditions, a deep red coloration.

Alizarin, the chief coloring matter of madder, is now produced artificially from coal tar in large quantities, though the madder is especially in request for woollen dyeing. This plant, which yielded such large revenues to the growers, is replaced by a cheaper manufactured product; very likely we should not have discovered the synthesis of its valuable dye, if our attention had not first been directed to it in the plant.

When it is remembered that coal tar is undoubtedly of vegetable origin, the many brilliant dyes derived from this source, are only evidences of what plant chemistry could have found in the carboniferous ages.

The following statistics show:

The amount[1] *of imported madder:*

	Pounds.	*Value.*
1884,	253,385	$13,521 00

Ground or prepared madder:

	Pounds.	*Value.*
1884,	1,458,313	$111,456 00
1885,	1,211,370	80,628 00

The natural or artificial alizarin:

	Pounds.	*Value.*
1884,	778,660	$296,123 00
1885,	1,470,864	404,002 00

Total value madder and alizarin:

1884,	$421,100 00
1885,	484,630 00

Many species of plants grown in different parts of the world, but especially the *Indigofera*, yield a glucoside called indican, which, under the influence of dilute mineral acids and certain ferments breaks up yielding indigo blue, and a substance resembling glucose.

"Indigo[2] has undoubtedly been known in Asia from a very

[1] Bureau of Statistics. 1885.

[2] *Hand-Book of Dyeing and Calico Printing.* W. Crookes, p. 447.

remote period of antiquity, since there exists in very ancient records, written in the Sanskrit language, descriptions of its mode of preparation mainly not different from the methods yet in use." The manner of cutting the plant and extracting the indigo is not the same in all countries. In India, the plants are grown from seed which are sown in the fall and spring, according to the kind of plant. As soon as the young plants are sufficiently forward they are replanted in regular rows. The flower buds are pulled off before they are fully developed, experience having taught that by so doing the leaves of the shrub become larger and yield more indigo, the coloring matter being chiefly present in the leaves.

The indigo of commerce is a blue dye stuff extracted by fermentation. Other plants[1] used occasionally for the extraction of indigo are more frequently employed directly in dyeing; they belong to the *Polygonaceæ* family. These plants are from India, China, Central Africa, and South America, and they can be acclimated in all warm countries. In the mode of indigo manufacture[2] two processes are employed. In the one the dry leaves are used, in the other the green leaves. This is the one in most common use. When the plant begins to flower it is cut down at about six inches from the ground and carried to the steeping vats with as little delay as possible, strewn horizontally into the vats, and pressed down by means of beams fixed into side posts, bamboo being placed under the beams. Water is immediately run in just sufficient to cover the plant. The pure water from the Ganges is especially sought for in these manufactories, and many indigo factories line the river banks. The time for steeping depends much on the temperature of the atmosphere, and can only be learned by experience and careful watching of the vats, but in close, sultry weather, with the thermometer at 96° in the shade, eleven or twelve hours are sufficient. In cooler weather more time is requisite.

When fermentation is established, the surface of the vat is covered with a violet scum. The liquid is drawn off through plug holes, in the wall of the vat. The fecula at the bottom is then removed to the boiler. It is brought to the boiling point as quickly as possible, and kept there for five or six hours. While boiling it is

[1] *Matières Premières Organiques.* Par Pennetier, p. 513.

[2] *Matières Premières Organiques*, p. 516. *Bul. de la Société Industrielle de Mulhouse*, vol. xxviii, p. 307.

stirred to keep the indigo from burning and skimmed with a perforated ladle. When sufficiently boiled it is run off to the straining table, where it remains twelve or fifteen hours draining. It is then taken to the presses and gradually pressed. This process takes twelve hours. It is then ready to be taken out, cut, stamped, and laid in the drying house to dry.

In the manufacture of indigo the ordinary processes of fermentation, drawing-off the liquor, beating, and collecting the fecula, are generally well known and are followed with but trifling variation in different provinces and manufactories in India. The main points appear to be the watching and the soaking of the plant so as to be able to tap-off the infused liquid exactly at the right point of fermentation, and next to beat the liquid in the second vat long enough.

Indigotin as it is contained in the vegetable tissues is colorless, but it becomes blue on contact with air. If it is desired to change indigo blue to indigo white, it is only necessary to place it in the presence of a de-oxidizing and alkaline liquid, but as soon as air is admitted its blue color is resumed.

The dyeing of fabrics is based upon the transformation of indigo blue into soluble indigo white. The colorless matter is placed on the stuff, which becomes blue by exposure. The solubility of indigo in sulphuric acid is utilized for blue dyeing of wools.

Indigo has been made artificially by several methods, though the process so far is too expensive to manufacture the compound to replace the commercial supply from plants.

The table of statistics is as follows:

Amount of indigo[1] *imported:*

	Pounds.	*Value.*
1884,	3,074·48	$2,267,048 00
1885,	3,035,934·	2,007,066 00

Artificial indigo:

	Pounds.	*Value.*
1884,	None,	. . .
1885,	3,300·	$3,600 00

The dye commonly known as logwood has been cultivated in Jamaica[2] since 1715, and has been known and used in Europe from

[1] Bureau of Statistics. 1885.

[2] *Crookes*, p. 342.

a short period after the discovery of America. The commercial supply of the dye is from *Hæmatoxylin campechianum*, a tree belonging to the natural order *Leguminosæ*. It is the wood of the tree which is used, and is met in commerce in the shape of large irregular blocks.

The only other tree besides logwood in which hæmatoxylin so far has been discovered, is the *Saraca indica* of the same natural order.

I stated[1] before the Academy of Natural Sciences, in November, the discovery of this principle in my analysis of the bark of the *Saraca indica*.

The *Saraca indica*[2] is called in India the asok or asoka tree, and it is said when this tree is in full blossom, there is nothing in the vegetable kingdom which affords a more beautiful object. Frequent mention is made of the plant in Hindoo mythology, and the bark is much used by native physicians in some diseases.

I undertook the analysis of this bark at the request of Messrs. Parke, Davis & Co., of Detroit, Mich., who liberally furnished me with a supply of the drug. The coloring principle exists in the bark in two or more conditions, as hæmatoxylin, and as oxidized products. The former was separated as yellow crystals, analogous in form to hæmatoxylin crystals from the true logwood The alcoholic extract of the bark contained about eighteen per cent. of a red-colored substance which agreed in color and dye tests with like constituents found in logwood. Mordanted cotton fabric was dyed with hæmatoxylin from Saraca bark, and presented the characteristic logwood dye colors.

The extracts of *Saraca indica* bark containing its coloring principle were tested with various reagents,[3] and it was observed that the reactions agreed with hæmatoxylin colors, and in no case with those of brazillin.

The bark of the commercial logwood tree is not used for extracting the dye, the wood of the tree being employed for this

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[1] "On Hæmatoxylin in the Bark of *Saraca Indica*." By Helen C. DeS. Abbott. *Proc. Acad. Nat. Sciences.* Phila., Nov. 30, 1886.

[2] *The Materia Medica of the Hindus.* By Udoy Chaud Dutt. Calcutta, 1877.

[3] S. P. Sadtler and W. L. Rowland. *Amer. Jour. Pharm.* Feb., 1881.

purpose. I determined the presence of a small quantity of hæmatoxylin in the logwood bark, and obtained with its extracts the same reaction without alkalies and other reagents as with the other wood extracts. But owing to the smaller percentage of dye in the bark of the specimens examined, the colors were less intense. In the case of the *Saraca indica* bark, the colors were very brilliant, and certainly indicated the presence of a large proportion of coloring matter in it. It would be of interest to secure specimens of the wood of *Saraca*, in order to determine if it contains the coloring principle, and should this be so, if it exists in sufficiently large quantities to warrant its introduction as a new source of this commercial product.

Last summer[1] I extracted from a Honduras plant, called "Chichipate," a yellow dye. It yielded with mordanted wool fabrics, colors resembling somewhat those yielded by fustic wood. A plant[2] was analyzed in the laboratory of Parke, Davis & Co., named *Cascara amargo*, from which a new alkaloid, pacramnine, was separated. This alkaloid is like berberine in its properties. Specimens of this plant were lately forwarded to me, and there is every indication of the relationship of identity of "Chichipate" and *Cascara amargo*. This incident is significant as deciding by means of chemical analysis the identity of plants under distinct names from different regions. No analysis under the name of "Chichipate" had ever been published until my own report. The dyeing property of the substance, chichipatin, separated from "Chichipate," I think is quite independent of the alkaloid, though berberine, it is well known, yields yellow colors with wool. I also separated a new camphor from this plant. It is crystalline, and under polarized light gives a beautiful play of colors.

During the year 1886, Prof. Trimble[3] separated a new crystalline camphor, phloxol from the underground portion of *Phlox carolina*. This substance resembles the camphor found in Chichipate. It is soluble in petroleum-ether, and this solvent is suggested

[1] "Preliminary Analysis of a Honduras Plant, named 'Chichipate.'" Paper read before the A. A. A. S., at Buffalo, August, 1886.

[2] "Cascara Amargo." By F. A. Thompson. *The Ther. Gazette*. January 15, 1884, p. 8.

[3] "An Analysis of the Underground Portion of *Phlox Carolina*." By Henry Trimble. *Amer. Jour. Phar.* October, 1886, p. 479.

as a means of distinguishing powdered *Phlox carolina* from *Spigelia*. The latter contains no camphor. *Phlox* is frequently put on the market for *Spigelia*. The two drugs in the normal condition can be readily identified.

An estimate of the profitable ends of the chemical analysis of plants may be gathered from the above statements.

Plant analysis covers a wide field, for it includes the chemistry of the living and the dead plant. Its application to various industries is far-reaching.

Plant analysis in this country has been called an "infant industry." There are probably differences of opinion about the infant needing protection It certainly needs encouragement and support, when its importance as a citizen is recognized.

Plant chemistry should not only be directed towards the study of new plants; but in the study of old plants it is to be encouraged; for each new investigation of many well-known plants has revealed new chemical principles, and given additional knowledge of the old ones. We can never know to what practical uses the constituents of any plants may be brought, and the money value of this information should be considered.

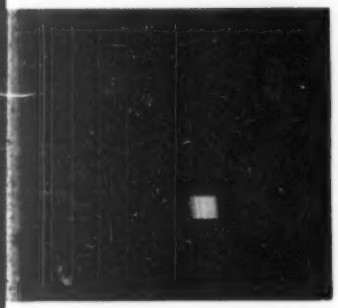
Many chemical compounds, which are of the most practical use now made by synthesis, were first discovered in plants, products of living matter.

Synthetical chemistry has derived its knowledge from the results of analytical study. Researches in plant analysis have revealed many facts, though the exploration field is still wide.

In our present state of knowledge, plant chemistry is a safe political ground for either the Protectionist or Free-Trader. The vegetable cell has placed the tariff of human penetration so high, and protected so well its industry, that the plant enjoys the monopoly of proteids and a magazine of other substances. The Free-Trader may console himself, for if he is intelligent enough he can find out the processes, and start his own factory, duty free.

Prof. Cohn, of Breslau, tells us that it is only a question of time when we may hope for the chemist to succeed in doing what the simplest *Algæ* and mosses are able to do, namely, to produce starch from carbonic acid and water. On that day the bread problem, which is in fact the greatest of all social problems, will be solved.

HENRY DRAPER MEMORIAL.



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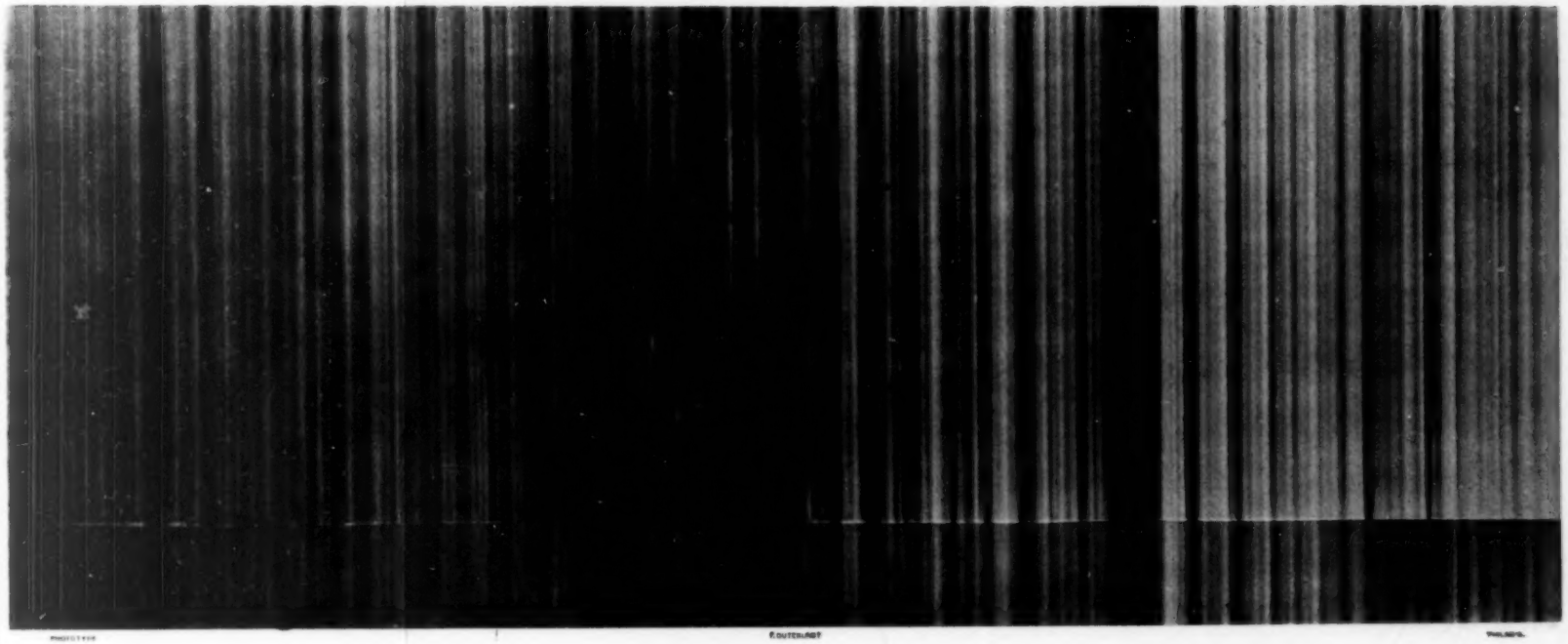


It is indeed true that those organic compounds, which are of the most importance in the life of the plant, the hydrocarbons, and the albuminoids are those which as yet have not permitted the secrets of their production to be discovered.

In the future, when synthesis has accomplished this prophecy and the synthetical chemist reigns supreme, our coming race to my imagination will be chemists, and our farmers will manufacture our food supply of proteids, sugars, and starch. The surface of the land will be one huge teeming laboratory. The plants, the analytical chemist and others of his race, asphyxiated by their environment, will have long ago passed away into a suffocating forgetfulness.

But, for the present, we must be satisfied to depend upon our humble colleagues, the plants, for our food and beverages; our fabrics, perfumes, and dye stuffs; our medicines, and other things too numerous to mention.

HENRY DRAPER MEMORIAL.

Dr. Henry Draper, in 1872, was the first to photograph the lines of a stellar spectrum. His investigation, pursued for many years with great skill and ingenuity, was most unfortunately interrupted in 1882 by his death. The recent advances in dry-plate photography have vastly increased our powers of dealing with this subject. Early in 1886, accordingly, Mrs. Draper made a liberal provision for carrying on this investigation at the Harvard College Observatory, as a memorial to her husband. The results attained are described below, and show that an opportunity is open for a very important and extensive investigation in this branch of astronomical physics. Mrs. Draper has accordingly decided greatly to extend the original plan of work, and to have it conducted on a scale suited to its importance. The attempt will be made to include all portions of the subject, so that the final results shall form a complete discussion of the constitution and conditions of the stars, as revealed by their spectra, so far as present scientific

methods permit. It is hoped that a greater advance will thus be made than if the subject were divided among several institutions, or, than, if a broader range of astronomical study were attempted. It is expected that a station to be established in the southern hemisphere will permit the work to be extended, so that a similar method of study may be applied to stars in all parts of the sky. The investigations already undertaken, and described below more in detail, include a catalogue of the spectra of all stars north of — 24° of the sixth magnitude and brighter, a more extensive catalogue of spectra of stars brighter than the eighth magnitude, and a detailed study of the spectra of the bright stars. This last will include a classification of the spectra, a determination of the wave-lengths of the lines, a comparison with terrestrial spectra, and an application of the results to the measurement of the approach and recession of the stars. A special photographic investigation will also be undertaken of the spectra of the banded stars, and of the ends of the spectra of the bright stars. The instruments employed are an eight inch Voigtländer photographic lens reground by Alvan Clark & Sons, and Dr. Draper's eleven-inch photographic lens, for which Mrs. Draper has provided a new mounting and observatory. The fifteen-inch refractor, belonging to the Harvard College Observatory, has also been employed in various experiments with a slit spectroscope, and is again being used as described below. Mrs. Draper has decided to send to Cambridge a twenty-eight-inch reflector and its mounting, and a fifteen-inch mirror, which is one of the most perfect reflectors constructed by Dr. Draper, and with which his photograph of the moon was taken. The first two instruments mentioned above have been kept at work during the first part of every clear night for several months. It is now intended that at least three telescopes shall be used during the whole night, until the work is interrupted by daylight.

The spectra have been produced by placing in front of the telescope a large prism, thus returning to the method originally employed by Fraunhofer in the first study of stellar spectra. Four 15° prisms have been constructed, the three largest having clear apertures of nearly eleven inches, and the fourth being somewhat smaller. The entire weight of these prisms exceeds 100 pounds, and they fill a brass cubical box a foot on each side. The spectrum

of a star formed by this apparatus is extremely narrow when the telescope is driven by clock-work in the usual way. A motion is accordingly given to the telescope slightly differing from that of the earth by means of a secondary clock controlling it electrically. The spectrum is thus spread into a band, having a width proportional to the time of exposure and to the rate of the controlling clock.

This band is generally not uniformly dense. It exhibits lines perpendicular to the refracting edge of the prism, such as are produced in the field of an ordinary spectroscope by particles of dust upon the slit. In the present case, these lines may be due to variations in the transparency of the air during the time of exposure, or to instrumental causes, such as irregular running of the driving clock, or slight changes in the motion of the telescope, resulting from the manner in which its polar axis is supported. These instrumental defects may be too small to be detected in ordinary micrometric or photographic observations, and still sufficient to affect the photographs just described.

A method of enlargement has been tried, which gives very satisfactory results, and removes the lines above mentioned as defects in the negatives. A cylindrical lens is placed close to the enlarging lens, with its axis parallel to the length of the spectrum. In the apparatus actually employed, the length of the spectrum, and with it the dispersion, is increased five times, while the breadth is made in all cases about four inches. The advantage of this arrangement is, that it greatly reduces the difficulty arising from the feeble light of the star. Until very lately, the spectra in the original negatives were made very narrow, since otherwise the intensity of the starlight would have been insufficient to produce the proper decomposition of the silver particles. The enlargement being made by daylight, the vast amount of energy then available is controlled by the original negative, the action of which may be compared to that of a telegraphic relay. The copies, therefore, represent many hundred times the original energy received from the stars. If care is not taken, the dust and irregularities of the film will give trouble, each foreign particle appearing as a fine spectral line.

Other methods of enlargement have been considered, and some of them tried, with the object of removing the irregularities of the

original spectra without introducing new defects. For instance, the sensitive plate may be moved during the enlargement in the direction of the spectral lines; a slit parallel to the lines may be used as the source of light, and the original negative separated by a small interval from the plate used for the copy; or, two cylindrical lenses may be used, with their axes perpendicular to each other. In some of these ways the lines due to dust might either be avoided or so much reduced in length as not to resemble the true lines of the spectrum.

The fifteen-inch refractor is now being used with a modification of the apparatus employed by Dr. Draper in his first experiments —a slit spectroscope from which the slit has been removed. A concave lens has been substituted for the collimator and slit, and, besides other advantages, a great saving in length is secured by this change. It is proposed to apply this method to the twenty-eight-inch reflector, thus utilizing its great power of gathering light.

The progress attained is best shown by the accompanying plate. *Fig. 1* is a direct copy of the spectra obtained in 1882. They were made by placing a 30° prism in front of a Voigtländer lens, having an aperture of two inches and a focal length of seven inches. The exposures lasted for about five minutes, and no clock-work was used. The instrument was directed successively to *α Lyræ*, *α Aquilæ*, *α Bootis*, and *β* and *γ Ursæ Minoris*, all of whose spectra appear in the figure. *Fig. 2* represents the spectra of *ζ Ursæ Majoris*, and of the adjacent fifth-magnitude star. It was taken with the eight-inch Voigtländer lens, with an exposure of five minutes, and illustrates the size of spectra used in preparing the catalogue of spectra of the brighter stars. One or two hundred of these spectra are sometimes photographed upon a single plate. *Fig. 3* was obtained with the Draper eleven-inch telescope, with two prisms. It represents the spectrum of *α Lyræ*, and was taken on November 5, 1886, with an exposure of fifty-nine minutes. *Fig. 4* was taken on January 21, 1887, in fifty minutes, with four prisms attached to the same instrument. It represents the spectrum of *β Geminorum*. All of these figures are reproduced directly from the original negatives, by the phototype process of F. Gutekunst, of Philadelphia. *Fig. 5* illustrates the method of enlargement described above. It represents the portions of *Fig. 4*

contained between the points marked *m* and *n*. The entire spectrum would, therefore, have a length nearly double that here represented. A less perfect spectrum of the same star was obtained on January 12, 1887. A portion of its enlargement is given in *Fig. 6*, adjacent to *Fig. 5*. Nearly all the lines of *Fig. 5* are shown less clearly in *Fig. 6*. Some of the remainder are due to the irregularities of the film described above, but they are probably too minute to be visible in the paper prints.

The results to be derived from the large number of photographs already obtained can only be stated after a long series of measurements and a careful reduction and discussion of them. An inspection of the plates, however, shows some points of interest. A photograph of *α Cygni*, taken November 26, 1886, shows that the *H* line is double, its two components having a difference in wave-length of about one ten-millionth of a millimetre. A photograph of *o Ceti* shows that the lines *G* and *h* are bright, as are also four of the ultra-violet lines characteristic of spectra of the first type. The *H* and *K* lines in this spectrum are dark, showing that they probably do not belong to that series of lines. The star near χ^1 *Orionis*, discovered by Gore in December, 1885, gives a similar spectrum, which affords additional evidence that it is a variable of the same class as *o Ceti*. Spectra of *Sirius* show a large number of faint lines besides the well-known broad lines.

The dispersion employed in any normal map of the spectrum may be expressed by its scale; that is, by the ratio of the wave-length as represented to the actual wave-length. It will be more convenient to divide these ratios by 1,000,000, to avoid the large numbers otherwise involved. If one-millionth of a millimetre is taken as the unit of wave-length, the length of this unit on the map in millimetres will give the same measure of the dispersion as that just described. When the map is not normal, the dispersion, of course, varies in different parts. It increases rapidly towards the violet end when the spectrum is formed by a prism. Accordingly, in this case the dispersion given will be that of the point whose wave-length is 400. This point lies near the middle of the photographic spectrum when a prism is used, and is not far from the *H* line. The dispersion may accordingly be found with sufficient accuracy by measuring the interval between the *H* and *K* lines, and dividing the result in millimetres by 3·4, since the

difference in their wave-lengths equals this quantity. The following examples serve to illustrate the dispersion expressed in this way: Angström, Cornu, 10; Draper, photograph of normal solar spectrum, 3·1 and 5·2; Rowland, 23, 33 and 46; Draper, stellar spectra, 0·16; Huggins, 0·1. *Fig. 1*, 0·06; *Fig. 2*, 0·10; *Fig. 3*, 0·63; *Fig. 4*, 1·3; *Figs.* 5 and 6, 6·5.

The most rapid plates are needed in this work, other considerations being generally of less importance. Accordingly, the Allen and Rowell Extra-Quick plates have been used until recently. It was found, however, that they were surpassed by the Seed Plates No. 21, which were accordingly substituted for them early in December. Recognizing the importance of supplying this demand for the most sensitive plates possible, the Seed Company has recently succeeded in making still more sensitive plates, which we are now using. The limit does not seem to be reached even yet. Plates could easily be handled if the sensitiveness were increased ten-fold. A vast increase in the results may be anticipated with each improvement of the plates in this respect. Apparatus for testing plates, which is believed to be much more accurate than that ordinarily employed, is in course of preparation. It is expected that a very precise determination will be made of the rapidity of the plates employed. Makers of very rapid plates are invited to send specimens for trial.

The photographic work has been done by Mr. W. P. Gerrish, who has also rendered important assistance in other parts of the investigation. He has shown great skill in various experiments which have been tried, and in the use of various novel and delicate instruments. Many of the experimental difficulties could not have been overcome but for the untiring skill and perseverance of Mr. George B. Clark, of the firm of Alvan Clark & Sons, by whom all the large instruments have been constructed.

The progress of the various investigations which are to form a part of this work is given below:

(1.) *Catalogue of Spectra of Bright Stars.*—This is a continuation of the work undertaken with the aid of an appropriation from the Bache Fund, and described in the *Memoirs of the American Academy*, vol. xi, p. 210. The eight-inch telescope is used, each photograph covering a region of 10° square. The exposures for equatorial stars last for five minutes, and the rate of the clock is

such that the spectra have a width of about 0·1 cm. The length of the spectra is about 1·2 cm. for the brighter, and 0·6 cm. for the fainter stars. The dispersion on the scale proposed above is 0·1. The spectra of all stars of the sixth magnitude and brighter will generally be found upon these plates, except in the case of red stars. Many fainter blue stars also appear. Three or four exposures are made upon a single plate. The entire sky north of — 24° would be covered twice, according to this plan, with 180 plates and 690 exposures. It is found preferable in some cases to make only two exposures; and when the plate appears to be a poor one, the work is repeated. The number of plates is therefore increased. Last summer, the plates appeared to be giving poor results. Dust on the prisms seemed to be the explanation of this difficulty. Many regions were re-observed on this account. The first cycle, covering the entire sky from zero to twenty-four hours of right ascension, has been completed. The work will be finished during the coming year by a second cycle of observations, which has already been begun. The first cycle contains 257 plates, all of which have been measured, and a large part of the reduction completed; 8,313 spectra have been measured on them, nearly all of which have been identified, and the places of a greater portion of the stars brought forward to the year 1900, and entered in catalogue form. In the second cycle, sixty-four plates have been taken, and about as many more will be required. Fifty-one plates have been measured and identified, including 2,974 spectra. A study of the photographic brightness and distribution of the light in the spectra will also be made.

The results will be published in the form of a catalogue resembling the Photo-metric Catalogue given in vol. xiv, of the *Annals of Harvard College Observatory*. It will contain the approximate place of each star for 1900, its designation, the character of the spectrum as derived from each of the plates in which it was photographed, the references to these plates, and the photographic brightness of the star.

(2.) *Catalogue of Spectra of Faint Stars.*—This work resembles the preceding, but is much more extensive. The same instrument is used, but each region has an exposure of an hour, the rate of the clock being such that the width of the spectrum will be as before 0·1 cm. Many stars of the ninth magnitude will thus be

included, and nearly all brighter than the eighth. In one case, over 300 spectra are shown on a single plate. This work has been carried on only in the intervals when the telescope was not needed for other purposes. Ninety-nine plates have, however, been obtained, and on these 4,442 spectra have been measured. It is proposed to complete the equatorial zones first, gradually extending the work northward. In all, 15,729 spectra of bright and faint stars have been measured.

(3.) *Detailed Study of the Spectra of the Brighter Stars.*—This work has been carried on with the eleven-inch photographic telescope used by Dr. Draper in his later researches. A wooden observatory was constructed about twenty feet square. This was surmounted by a dome having a clear diameter of eighteen feet on the inside. The dome had a wooden frame, sheathed and covered with canvas. It rested on eight cast-iron wheels, and was easily moved by hand, the power being directly applied. Work was begun upon it in June, and the first observations were made with the telescope in October. Two prisms were formed by splitting a thick plate of glass diagonally. These gave such good results that two others were made in the same way, and the entire battery of four prisms is ordinarily used. The safety and convenience of handling the prisms is greatly increased by placing them in square brass boxes, each of which slides into place like a drawer. Any combination of the prisms may thus be employed. As is usual in such an investigation, a great variety of difficulties have been encountered, and the most important of them have now been overcome.

(4.) *Faint Stellar Spectra.*—The twenty-eight-inch reflector will be used for the study of the spectra of the faint stars, and also for the fainter portions near the ends of the spectra of the brighter stars. The form of spectroscope mentioned above, in which the collimator and slit are replaced by a concave lens, will be tried. The objects to be examined are, first, the stars known to be variable, with the expectation that some evidence may be afforded of the cause of the variation. The stars whose spectrum is known to be banded, to contain bright lines, or to be peculiar in other respects, will also be examined systematically. Experiments will also be tried with orthochromatic plates and the use of a colored absorbing medium, in order to photograph the red portions of the

spectra of the bright stars. Quartz will also be tried to extend the images towards the ultra-violet.

(5.) *Absorption Spectra.*—The ordinary form of comparison spectrum cannot be employed on account of the absence of a slit. The most promising method of determining the wave-lengths of the stellar spectra, is to interpose some absorbent medium. Experiments are in progress with hyponitric fumes and other substances. A tank containing one of these materials is interposed, and the spectra photographed through it. The stellar spectra will then be traversed by lines resulting from the absorption of the media, thus interposed, and, after their wave-lengths are once determined, they serve as a precise standard to which the stellar lines may be referred. The absorption lines of the terrestrial atmosphere would form the best standard for this purpose if those which are sufficiently fine can be photographed.

(6.) *Wave-Lengths.*—The determination of the wave-lengths of the lines in the stellar spectra will form an important part of the work which has not yet been begun. The approximate wave-lengths can readily be found from a comparison with the solar spectrum, a sufficient number of solar lines being present in most stellar spectra. As a difference of one ten-millionth of a millimetre in wave-length exceeds half a millimetre in *Figs. 5* and *6* of the accompanying plate, the readings may be made with considerable accuracy by a simple inspection. For greater precision, special precautions are necessary on account of the deviation caused by the approach and recession of the stars. The deviation found by Dr. Huggins in the case of *Sirius* would correspond to a change in the position of the lines of *Figs. 5* and *6* of about half a millimetre. If, then, satisfactory results are obtained in the preceding investigation, the motion of the stars can probably be determined with a high degree of precision. The identification of the lines with those of terrestrial substances will, of course, form a part of the work, but the details will be considered subsequently.

From the above statement, it will be seen that photographic apparatus has been furnished on a scale unequalled elsewhere. But what is more important, Mrs. Draper has not only provided the means for keeping these instruments actively employed, several of them during the whole of every clear night, but also of reducing the results by a considerable force of computers, and of publishing

them in a suitable form. A field of work of great extent and promise is open, and there seems to be an opportunity to erect to the name of Dr. Henry Draper a memorial such as heretofore no astronomer has received. One cannot but hope that such an example may be imitated in other departments of astronomy, and that hereafter other names may be commemorated, not by a needless duplication of unsupported observatories, but by the more lasting monuments of useful work accomplished.

EDWARD C. PICKERING,

Director of Harvard College Observatory.

Cambridge, Mass., U. S. A., March 1, 1887.

THE USE OF OIL FOR STILLING WAVES: WITH A DESCRIPTION OF A NEW OIL DISTRIBUTOR FOR THE USE OF MARINERS.

BY T. F. TOWNSEND, of Philadelphia.

[*A Paper read before the* FRANKLIN INSTITUTE, *at the Stated Meeting held Wednesday, April 20, 1887.*]

JOSEPH M. WILSON, President, in the Chair.

MR. TOWNSEND: The stilling of waves by means of oil, was known to the Ancients, and is mentioned in the writings of Plutarch, Pliny and Aristotle.

Its application for quieting rough waters, has long been practiced by whalemen, fishermen, and divers in their avocations, but its more general use, continuously applied in small quantities, during severe storms, by merchantmen, for securing their comfort and safety, is of comparatively recent date.

Had there been no potency in "pouring oil on troubled waters," it is hardly likely that the saying would have become so well known, and so often used as a comparison. The origin of the maxim I am unable to give, as I have never seen it used, except as a quotation.

Owing to so many recent publications of the experience of those who have tested the action of oil on high seas, the public is becoming much interested in the subject, and is curious to know

if it is a fact, that so simple a means will produce such decided results.

If we can believe the evidence of the many competent judges, who have made practical experiments, its efficacy is established almost beyond a doubt.

The subject possesses also much interest from a scientific point of view.

Franklin, who was ever on the alert for those things which escape the observation of ordinary persons, did not fail to notice the peculiar effect of oil on water, and his philosophical mind did not rest until he had investigated the subject.

Some of the results of those investigations are embodied in the following extracts of papers read before the Royal Society, June 2, 1774. They are so thorough and clear, as to cause and effect, that I cannot do better justice to the subject, than to reproduce them before the Society bearing his honored name.

Extract of a letter from the Rev. Mr. Farish to Dr. Brownrigg:

I sometime ago met with Dr. Dun, who surprised me with an account of an experiment you had tried upon the Derwent Water, in company with Sir John Prindle and Dr. Franklin. According to his representations, the water, which had been in great agitation before, was instantly calmed upon pouring in only a very small quantity of oil, and that to so great a distance round the boat as seemed incredible.

I have since had the same accounts from others, but I suspect all of a little exaggeration.

Pliny mentions this property of oil as known particularly to the divers, who made use of it in his days, in order to have a more steady light at the bottom.

The sailors, I have been told, have observed something of the same kind in our days, that the water is always remarkably smoother in the wake of a ship that has been newly tallowed than it is in one that is foul.

Mr. Pennant also mentions an observation of the like nature made by the seal catchers in Scotland.* When these animals are devouring a very oily fish, which they always do under water, the waves above are observed to be remarkably smooth, and by this mark the fisherman know where to look for them.

Old Pliny does not usually meet with all the credit I am inclined to think he deserves. I shall be glad to have an authentic account of the Keswick experiment, and, if it comes up to the representations that have been made of it, I shall not much hesitate to believe the old gentleman in another more wonderful phenomenon he relates, of stilling a *tempest* only by throwing up a little vinegar into the air.

* *Brit. Zool.*, vol. iv, article "Seal."

Extract of a letter to Dr. Brownrigg, from Dr. Franklin, dated London, 7 November, 1773.

Dear Sir:—I thank you for the remarks of your learned friend at Carlisle. I had, when a youth, read and smiled at Pliny's account of a practice among seamen of his time, to still the waves in a storm by pouring oil into the sea, which he mentions, as well as the use made of oil by the divers; but the stilling a tempest by throwing vinegar into the air had escaped me. I think, with your friend, that it has been of late too much the mode to slight the learning of the Ancients. The learned, too, are apt to slight too much the knowledge of the vulgar.

The cooling by evaporation was long an instance of the latter. This art of smoothing the waves by oil is an instance of both.

* * * * * * * * *

In 1757, being at sea in a fleet of ninety-six sail bound against Louisbourg, I observed the wakes of two of the ships to be remarkably smooth, while all the others were ruffled by the wind, which blew fresh. Being puzzled with the differing appearance, I at last pointed it out to our captain, and asked him the meaning of it. "The cooks," says he, "have, I suppose, been just emptying their greasy water through the scuppers, which has greased the sides of those ships a little." And this answer he gave me with an air of some little contempt, as to a person ignorant of what everybody else knew. In my own mind, I at first slighted his solution, though I was not able to think of another; but recollecting what I had formerly read in Pliny, I resolved to make some experiment of the effect of oil on water, when I should have opportunity.

* * * * * * * * *

An old sea captain told me he had heard it was a practice with the fishermen of Lisbon, when about to return into the river (if they saw before them too great a surf upon the bar, which they apprehended might fill their boats in passing) to empty a bottle or two of oil into the sea, which would suppress the breakers, and allow them to pass safely.

A confirmation of this I have not since had an opportunity of obtaining; but discoursing of it with another person, who had often been in the Mediterranean, I was informed that the divers there, who, when under water, in their business, need light, which the curling of the surface interrupts by refractions of so many little waves, let a small quantity of oil now and then out of their mouths, which, rising to the surface smooths it, and permits the light to come down to them. All these informations I at times revolved in my mind, and wondered to find no mention of them in our books of experimental philosophy.

At length being at Clapham, where there is, on the common, a large pond, which I observed one day to be very rough with the wind, I fetched out a cruet of oil, and dropped a little of it on the water. I saw it spread itself with surprising swiftness upon the surface, but the effect of smoothing the waves was not produced; for I had applied it first on the leeward side of the pond where the waves were largest, and the wind drove my oil back upon the shore.

I then went to the windward side, where they began to form; and there the oil, though not more than a teaspoonful, produced an instant calm over a space several yards square, which spread amazingly, and extended itself gradually till it reached the lee side, making all that quarter of the pond, perhaps half an acre, as smooth as a looking-glass.

After this I contrived to take with me, whenever I went into the country, a little oil in the upper hollow joint of my bamboo cane, with which I might repeat the experiment as opportunity should offer, and I found it constantly to succeed.

In these experiments, one circumstance struck me with particular surprise. This was the sudden, wide and forcible spreading of a drop of oil on the face of the water, which I do not know that anybody has hitherto considered.

If a drop of oil is put on a highly polished marble table, or on a looking glass that lies horizontally, the drop remains in its place, spreading very little. But, when put on the water, it spreads instantly many feet round, becoming so thin as to produce the prismatic colors, for a considerable space, and beyond them so much thinner as to be invisible, except in its effect of smoothing the waves at a much greater distance.

It seems as if a mutual repulsion between its particles took place as soon as it touched the water, and a repulsion so strong as to act on other bodies swimming on the surface, as straw, leaves, chips, etc., forcing them to recede every way from the drop, as from a centre, leaving a large, clear space.

The quantity of this force, and the distance to which it will operate, I have not yet ascertained; but I think it a curious inquiry, and I wish to understand whence it arises.

* * * * * * * * * *

Our friend, Sir John Pringle, being soon after in Scotland, learned there, that those employed in the herring fishery could at a distance see where the shoals of herrings were, by the smoothness of the water over them, which might possibly be occasioned, he thought, by some oiliness proceeding from their bodies. A gentleman from Rhode Island told me it had been remarked that the harbor of Newport was ever smooth while any whaling vessels were in it, which probably arose from hence, that the blubber which they sometimes bring loose in the hold, or the leakage of their barrels, might afford some oil, to mix with that water, which from time to time they pump out, to keep their vessel free, and that some oil might spread over the surface of the water in the harbor, and prevent the forming of any waves.

This prevention I would thus endeavor to explain:

There seems to be no natural repulsion between water and air, such as to keep them from coming into contact with each other. Hence we find a quantity of air in water, and if we extract it by means of the air pump, the same water, again exposed to the air, will soon imbibe an equal quantity.

Therefore, air in motion, which is wind, in passing over the smooth surface of water, may rub, as it were, upon that surface and raise it in wrinkles, which, if the wind continues, are the elements of future waves.

* * * * * * * * *

Thus, the small, first-raised waves, being continually acted upon by the wind, are, though the wind does not increase in strength, continually increased in magnitude, rising higher and extending their bases, so as to include a vast mass of water in each wave, which, in its motion, acts with great violence.

But if there be a mutual repulsion between the particles of oil, and no attraction between oil and water, oil dropped on water will not be held together by adhesion to the spot whereon it falls; it will not be imbibed by the water; it will be at liberty to expand itself; and it will spread on a surface that, besides being smooth to the most perfect degree of polish, prevents, perhaps by repelling the oil, all immediate contact, keeping it at a minute distance from itself; and the expansion will continue till the mutual repulsion between the particles of the oil is weakened and reduced to nothing by their distance.

Now, I imagine that the wind, blowing over water thus covered by a film of oil, cannot easily *catch* upon it, so as to raise the first wrinkles, but slides over it, and leaves it as smooth as it finds it. It moves a little the oil indeed, which, being between it and the water, serves it to slide with, and prevents friction, as oil does between those parts of a machine that would otherwise rub hard together.

Hence, the oil dropped on the windward side of a pond proceeds gradually to leeward, as may be seen by the smoothness it carries with it, quite to the opposite side. For the wind being thus prevented from raising the first wrinkles—that I call the elements of a wave—cannot produce waves, which are to be made by continually acting upon and enlarging those elements, and thus the whole pond is calmed.

Totally, therefore, we might suppress the waves in any required place, if we could come at the windward place where they take their rise. This, in the ocean, can seldom if ever be done. But perhaps something may be done on particular occasions to moderate the violence of the waves when we are in the midst of them, and prevent their breaking, where that would be inconvenient.

For, when the wind blows fresh, there are continually rising on the back of every great wave a number of small ones, which roughen its surface and give the wind hold, as it were, to push it with greater force. This hold is diminished by preventing the generation of those small ones. And possibly, too, when a wave's surface is oiled, the wind in passing over it may rather in some degree press it down, and contribute to prevent its rising again, instead of promoting it. This, as mere conjecture, would have little weight if the apparent effects of pouring oil into the midst of waves were not considerable, and as yet not otherwise accounted for.

When the wind blows so fresh as that, the waves are not sufficiently quick in obeying its impulse; their tops being thinner and lighter, are pushed forward, broken, and turned over in a white foam. Common waves lift a vessel without entering it; but these, when large, sometimes break above and pour over it, doing great damage.

But that this effect might in any degree be prevented, or the height and

violence of waves in the sea moderated, we had no certain account, Pliny's authority for the practice of seamen in his time being slighted.

Discoursing lately on this subject with his excellency, Count Bentinck, of Holland, his son, the Honorable Capt. Bentinck, and the learned professor, Allemand, a letter was mentioned, which had been received by the Count from Batavia, relative to the saving of a Dutch ship, in a storm, by pouring oil into the sea. I much desired to see that letter, and a copy of it was promised me, which I afterward received.

Extract of the letter from Mr. Tengnagel to Count Bentnick, dated Batavia, 5 January, 1770.

Near the islands Paul and Amsterdam, we met with a storm, which had nothing particular in it worthy of being communicated to you, except that the captain found himself obliged for greater safety in wearing the ship, to pour oil into the sea, to prevent the waves breaking over her, which had an excellent effect, and succeeded in preserving us. As he poured out but a little at a time, the East India Company owes perhaps its ship to only six demi-ames of olive oil.

I was present upon deck when this was done; and I should not have mentioned this circumstance to you, but that we have found people here so prejudiced against the experiment, as to make it necessary for the officers on board and myself to give a certificate of the truth on this head, of which we made no difficulty. * * *

Coming down to a later period, Capt. Anthony Jerome, ship *Black Warrior*, whaler, in the Arctic seas, makes the following statement:

The oil escaping through the lance wounds of a whale, always makes a slick to leeward, and it is well known to whalers that the pumping of bilge water from their ships, which is always more or less impregnated with oil will produce a slick.

In the year 1852, at the entrance of Behring's Straits, experienced a fearful gale and sea, soon after fastening to two sperm whales. Secured the ship to them with 600 feet of line, and rode out the gale with dry decks, in the smooth caused by the oil from the whales.

At another time was caught out in a heavy gale in a whale boat. Could not return to the ship. Made fast to a dead whale, with 100 feet of line, and laid in slick all night perfectly dry.

Capt. John Ward, ship *Electra*, off Tristan d'Acunha, South Atlantic, put long line to dead sperm whale, and rode out a fearful gale, with perfectly dry decks. Again, when on ship *General Williams*, he rode out a gale of four days' duration, while attached by long line to a large right whale, no water coming on deck during the whole gale.

The smooth sea, or slick, always to leeward of a dead whale is vouched for by numerous captains, and many cases can be cited of whalemen who have taken advantage of the smooth sea thus formed and have been saved much discomfort, alarm and danger.

The array of facts establishing the efficacy of oil in smoothing rough seas is so numerous, that the question naturally arises; Why has its general use been so long delayed?

I think there are several reasons.

Until recently, there were many who had never heard of the use of oil for quieting waves, though their whole lives had been spent at sea. Some were skeptical and indifferent, and others supposed that in order to derive any beneficial result, the oil must be used in large quantities. A few, perhaps, would have used it, had they been provided with proper appliances for its distribution. Very few ships have been in the habit of carrying as stores, a sufficient quantity of oil to spare for wave oiling, not even the small amount necessary to use through one storm. No doubt, many shipwrecks have occurred, which might have been prevented, had the oil at hand been used, instead of letting it remain securely sealed up.

The Hydrographic Office deserves much credit for the interest created in the use of oil, and the information it has given to mariners regarding its application and effectiveness, by collecting and publishing the experiences of those who have experimented with it. A portion of its monthly *Pilot Chart* has been devoted to these reports, thus keeping the subject constantly before those most interested. These reports have since been published in book form by the Hydrographic Office for general distribution.

From pamphlet No. 83, entitled "The Use of Oil to Lessen the Dangerous Effect of Heavy Seas," I quote the following:

> Experience seems to demonstrate that the thick and heavy oils are generally the best for this purpose. Mineral oils are not so effective as vegetable or animal, and, therefore, the use of the first-named is not recommended when either of the latter is available. It may be remarked in this connection that crude petroleum probably gives good results in smoothing heavy seas, but its usefulness in this direction decreases in proportion to the degree to which it has been refined.
>
> It would be well to remember that soft oils, such as fish oils, cocoanut oil, and others of a like nature, become thick and useless when exposed to a very cold temperature, and if it becomes necessary to use them under this condition, it is advisable that they be mixed with some mineral oil, which has a much lower cold-test.

A comparatively small amount of oil, say two quarts per hour, properly used, is sufficient to prevent great damage both to vessels and small boats in heavy seas.

The greatest effect from oil is obtained when in deep water. In a surf, or where water is breaking on a bar, the effect of the oil is not so certain, but even in this case it may be of benefit, and its use is recommended.

In order to get the best possible effect from oil, it must be applied in such a way as to spread to windward.

It is effective when scudding, when lying-to, when wearing, and when lowering and hoisting boats in a heavy sea.

The best results seem to be secured by pouring it into the bowls of water-closets in which oakum has been placed, whence it slowly leaks out; and by means of canvas bags, having a capacity from one to two gallons. Oakum is stuffed in these bags, and they are punctured with a coarse sail-needle to facilitate the escape of the oil. In running before the wind, these bags should be suspended by lanyards from each cat-head and allowed to drag in the water. In lying-to, the weather-bow and mizzen-chains seem to be the best places for the bags, with sufficiently long lines to allow them to tend to windward while the ship drifts. In crossing a bar on a flood tide some oil should be put overboard and allowed to float in ahead of the boat, which should follow with an oil-bag towing astern. In crossing a bar against an ebb tide, no advantage can be obtained by using oil from the boat. For boarding a wreck, a vessel should run as close as possible under the lee of the wreck and put the oil over. The wreck will soon drift down into the oil, when a boat can be sent alongside of her most favorably. In the case of a boat riding to a sea-anchor in heavy weather, the oil-bag should be secured to an endless line rove through a block at the sea-anchor, by means of which the oil is spread well ahead of the boat, and when the bag is empty, it can be hauled on board and replenished. A similar system could be employed to advantage by the fishermen on the banks.

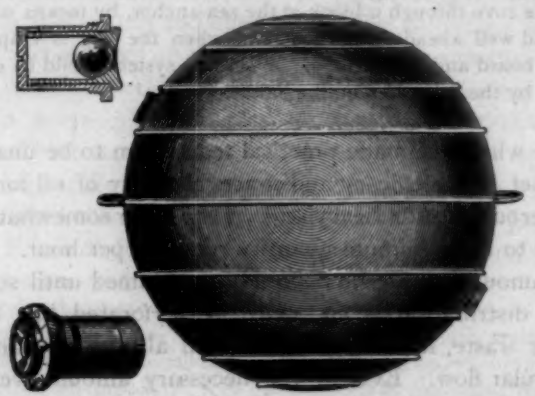
Those who have made practical tests seem to be unanimous in their belief in the efficacy and practical utility of oil for lessening the dangerous effect of heavy seas. They differ somewhat in opinion in regard to the minimum quantity required per hour.

This amount cannot be definitely ascertained until some better mode of distribution is adopted. A perforated bag containing oakum or waste, saturated with oil, will always give an uncertain and irregular flow. Even if the necessary amount were known, it would be an impossibility to so perforate a bag that it would give forth a pre-determined quantity.

This uncertainty makes the bag objectionable, especially for use at night. Excessive quantities of oil are apt to be used in order to be on the safe side, and on this account, the use of the bag

ceases to be economical. After using, it is apt to be stowed away out of sight, in some locker, to save for future use, and it then becomes quite as dangerous as heavy seas, by the possible and probable danger of its becoming a fire-brand from spontaneous combustion.

In view of these facts and the many inquiries for some better mode for distributing the oil, I have devised an oiler, which, I believe, to be philosophic in principle, simple in construction and adapted for the purpose in question. My device (*see engravings*) consists



of a hollow metal globe, ten inches in diameter, and about one and one-half gallons capacity. To protect it from injury and to add to its strength, heavy wire rings are soldered around the outside.

It has an air chamber to float it in an upright position, and an upper and lower valve to regulate the flow of the contents. By

means of a ball in the upper valve, the flow of oil is stopped automatically, when action is not desired.

When filled with oil, the upper valve is adjusted to give vent to the oil in any desired quantity, and the lower valve is set to admit the water. When placed in the sea, the water coming in at the lower valve, by reason of its greater specific gravity, steadily and regularly displaces the oil, which flows out through the upper graduated valve.

After the vessel has emptied itself of oil, it should be taken in and refilled, or replaced by another. When it is not practical or desirable to put it in the sea, it can be placed in the bowl of the water closet, or used as a drip by securing it to any portion of the ship. The flow will be regulated by the valves.

A piece of tubing leading from the valve to the water may be used to prevent the oil from blowing to leeward.

The portability of this oiler adapts it for use in any part of the ship, or for small boats. As it is buoyant, it can be anchored to protect any place or wreck while landing passengers or crew.

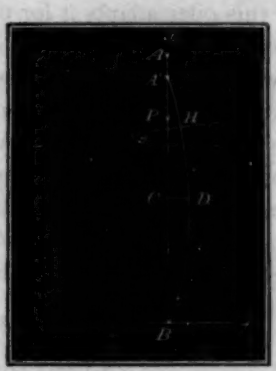
Its capacity for distribution ranges from one pint to two gallons per hour in a continuous and regular flow. When not in service, it can be put away and is always ready for immediate use.

Its small cost, its economical use of oil, its certainty of action, and its adaptation to all the conditions in which wave oiling can be made beneficial, make it a desirable distributor.

NOTE ON LONG COLUMNS.

By WM. CAIN, Prof. Math. and Eng., S. C. Mil. Academy.

In none of the various discussions of long columns that have appeared from time to time in the American journals, have I seen a reference to a formula given by Bresse (in his *Mécanique Appliquée*, première partie, p. 372,) who takes for the reciprocal of the radius of curvature, the correct expression $\frac{d\theta}{ds}$ in place of the usual approximation $\frac{d^2y}{dx^2}$ and thus deduces ultimately a more satisfactory form than the well known Euler's formula.



It may be of interest, therefore, to give a brief statement of Bresse's analysis with comments; likewise to deduce a formula that involves a criticism of the Rankine formula, with a mention of other formulæ that have been recently proposed as representing the results of experiments. Thus, let the axis of the column $A\ B$ in the figure, *hinged at the ends*, take the position $A'\ B$ under the action of the force P directed from A to B. Now, in the beginning, we must note a radical defect in all column formulæ in this; that if the column is prismatic and homogeneous and P acts along the axis, supposed originally straight, the column should decrease in length somewhat, but *remain straight* after P is applied, since the compression is uniform throughout. There is thus no possibility

for the column to deflect, unless the force P is eccentrically applied, or the column is either not straight or not homogeneous.

Practically, the column deflects originally from some of these causes, but as they are accidental, they are not included in the analysis, which simply expresses the conditions of equilibrium between the force P and the molecular actions developed in any section whatsoever of the column, as at H, after the column is in some *accidental way*, not included in the formula sprung out of line, and afterward the accidental cause is removed.

It can hardly be expected that a formula that leaves out an important part of the actual conditions of the case, should give absolutely correct results; it is, moreover, incorrect to expect the formula, deduced on the supposition of perfect elasticity, to give results agreeing with experiments on the so-called *breaking strength* of columns, if the limit of elasticity has been much exceeded, so that Hooke's law no longer holds, even approximately.

Bearing in mind then, that the formula that will be deduced, does not account for *how* the column became bent in the first instance, we shall proceed to express the conditions of equilibrium necessary to keep it bent after the first cause has been removed. Thus, we shall call ds the primitive length of an element of the axis at H, and θ the inclination of the section at this point to its original horizontal direction. The section infinitely near this, which was originally at the distance ds, makes now the angle $d\theta$ with the other section.

Hence, calling y the horizontal ordinate to the axis of the curve, we have the conditions of equilibrium between the molecular stresses and the force P, given by the known equation of moments,

$$e r^2 \frac{d\theta}{ds} = P y \qquad (1)$$

where $e = E Q$ or the product of the modulus of elasticity by the area of the cross section and r represents the radius of gyration.

The element whose original length was ds, has now, in consequence of the uniform compression P, a new length ds'; whence

$$ds' = ds\left(1 - \frac{P}{e}\right) \qquad (2)$$

on neglecting the small inclination of P to the normal at the section.

Finally, since the component of P parallel to the section is also very small, it is permitted to neglect the influence of transverse shearing, and to regard a section originally normal to the axis as likewise normal after deformation. Hence, regarding x and y as the co-ordinates of the final elastic curve,

$$-ds' \sin\theta = dy \tag{3}$$

From equations (2) and (3), we find

$$\frac{dy}{ds} = -\sin\theta\left(1-\frac{P}{e}\right),$$

which substituted in (1), after having differentiated it in relation to s, gives

$$e\,r^2\frac{d^2\theta}{ds^2} = -P\left(1-\frac{P}{e}\right)\sin\theta;$$

whence, multiplying by $2\,d\theta$ and integrating, we have

$$e\,r^2\left(\frac{d\theta}{ds}\right)^2 = 2P\left(1-\frac{P}{e}\right)\cos\theta + C$$

If we call θ_0 the value of θ at A', and make $y = o$ when $\frac{d\theta}{ds} = o$ from (1), we can determine C in terms of θ_0:

$$\therefore e\,r^2\left(\frac{d\theta}{ds}\right)^2 = 2P\left(1-\frac{P}{e}\right)(\cos\theta - \cos\theta_0) \tag{4}$$

or

$$\frac{d\theta}{\sqrt{2(\cos\theta-\cos\theta_0)}} = \frac{ds}{r}\sqrt{\frac{P}{e}\left(1-\frac{P}{e}\right)}$$

The integral of the second number of this equation, between the limits $s = o$ and $s = A\,B = 2\,a$ is $\frac{2a}{r}\sqrt{\frac{P}{e}\left(1-\frac{P}{e}\right)}$; the integral of the first between the same limits is known from the theory of the simple pendulum. If θ becomes zero i times between B and A', this integral will be the time of i oscillations of a simple pendulum, having for a length the number g, or the acceleration due to gravity; we should have then approximately for its value $i\pi\left(1+\frac{\theta_0^2}{16}\right)$, neglecting in the differential expression powers of θ_0

superior to the fourth ;* consequently we have

$$i\pi\left(1+\frac{\theta_0^2}{16}\right) = \frac{2a}{r}\sqrt{\frac{P}{e}\left(1-\frac{P}{e}\right)}. \qquad (5)$$

Now equations (1) and (4) applied to points, such as D, for which θ becomes zero at the same time that y takes a maximum value f, give

$$e r^2 \frac{d\theta}{ds} = Pf,$$

$$e r^2 \left(\frac{d\theta}{ds}\right)^2 = 2P\left(1-\frac{P}{e}\right)(1-\cos\theta_0),$$

from which we draw

$$\frac{Pf^2}{e r^2} = 2\left(1-\frac{P}{e}\right)(1\cos\theta_0)$$

or in consequence of the smallness of θ_0, since

$$2(1-\cos\theta_0) = 2(1-1+\tfrac{1}{2}\theta_0^2-\ldots) = \theta_0^2,$$

nearly,

$$\frac{Pf^2}{e r^2} = \left(1-\frac{P}{e}\right)\theta_0^2 \qquad (6)$$

Eliminating θ_0 between (5) and (6), we find

$$\frac{Pf^2}{e r^2\left(1-\frac{P}{e}\right)} = 16\left[\frac{2a}{i\pi r}\sqrt{\frac{P}{e}\left(1-\frac{P}{e}\right)}-1\right] \qquad (7)$$

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* From the formula,

$$\cos x = 1-\frac{x^2}{2}+\frac{x^4}{2.3.4}-\ldots$$

we have,

$$2(\cos\theta-\cos\theta_0) = \theta_0^2-\theta^2-\frac{1}{12}\left(\theta_0^4-\theta^4\right)$$

$$= \left(\theta-\theta^2\right)\left[1-\frac{1}{12}\left(\theta_0^2+\theta^2\right)\right];$$

neglecting powers of θ higher than the fourth.

Whence

$$2i\int_0^{\theta_0}\frac{d\theta}{\sqrt{2(\cos\theta-\cos\theta_0)}} = 2i\int_0^{\theta_0}\frac{d\theta}{\sqrt{\theta_0^2-\theta^2}}\left[1-\frac{1}{12}\left(\theta_0^2+\theta^2\right)\right]^{-\frac{1}{2}}$$

$$= 2i\int_0^{\theta_0}\left(1+\frac{1}{24}\theta_0^2+\frac{1}{24}\theta^2\right)\frac{d\theta}{\sqrt{\theta_0^2-\theta^2}} = i\pi\left(1+\frac{\theta_0^2}{16}\right).$$

a formula from which the greatest deflection f can be found for an assumed load P, and vice-versa. There is evidently no deflection when the [ ] in the right number is negative; so that by placing it equal to zero, we can find the lower limit of P, at which the previous theory begins to be applicable. For slightly greater values of P, f becomes appreciable and the bending is permanent, since the *moment* $(P\,y)$ at any cross section by equation (1) exactly balances the *moment* of *all* the normal molecular stresses at the cross section. We say *all* advisedly since the stresses at the section due to flexure alone, added to those caused by the uniform compression P, together form the real stresses there whose *moment*, however, about an axis of flexure passing through the axis of the beam, is equal to the moment of the stresses that would be caused by flexure alone. We see, therefore, that the uniform stress is not neglected in the investigation; but that equation (7) represents the conditions of equilibrium between the force P and the molecular stresses when, *after the beam has been bent from some accidental cause, the cause is removed, and the force P is sufficient to keep the beam bent to an extent given by the formula.* Increasing the load, increases the deflection f, so that we can compute the value of P corresponding to any value of f assumed as safe.

The formula does not apply to *safe loads*, for such values of P will always be found to be too small to keep the column bent, even if it should be sprung out of line in some accidental way, so that the formula is no longer applicable, and direct uniform compression is alone to be provided for at each cross section; so that in any practical case the theory of bending does not come in at all, though possibly a little deflection is in practice always experienced from eccentricity of the load, crookedness and want of homogeneity of the column, none of which items can be included in the formula, as they vary for each separate column and cannot be known before-hand.*

This strictly exact theoretical formula (7) enables us to ascertain the minimum theoretical load at which bending can be just main-

* Hodginson says in this connection: "I have many times sought experimentally, with great care, for the weight producing incipient flexure (in columns) according to the theory of Euler, but have hitherto been unsuccessful. So far as I can see, flexure commences with weights far below those with which pillars are usually loaded in practice.

tained, which can be found by putting the quantity in [ ] equal to zero, and solving for P. If we neglect $\frac{P}{e} = \frac{P}{E\,Q}$ as very small in comparison with 1 (since it represents the shortening of the column per unit of length), we derive, in the way mentioned, the well known Euler's formula,

$$P = \left(\frac{i\,\pi}{2\,a}\right)^2 e\,r^2 = \left(\frac{i\,\pi}{2\,a}\right)^2 E\,I \qquad (8)$$

giving the least value to P, at which bending can just begin to be maintained for i repetitions of the curvature shown by the figure. The least force is $P = \left(\frac{\pi}{2\,a}\right)^2 E\,I$, corresponding to $i = 1$. By making $i = 2, 3, \ldots$, we have values of P, equal to the first multiplied by $4, 9, \ldots$; so that the column cannot remain bent if it does not slightly exceed the lower limit $\frac{\pi^2}{4\,a^2}\,E\,I$. But since equilibrium can possibly subsist for $4, 9, \ldots$ times the value, if the curvature is compounded, we have another reason for not expecting the results of all experiments to agree with one formula (8), where i is only given one of its possible values, as is usual.

If desired, we can write a slightly more accurate formula for P by not confounding the final and primitive lengths of the column, as was done in deducing (8). Thus where bending is just about to begin the [ ] in (7) is zero, which gives for the least value of $\frac{P}{e}$ corresponding,

$$\frac{P}{e} = \frac{1}{2}\left(1 - \sqrt{1 - \frac{i^2\,\pi^2\,r^2}{a^2}}\right)$$

or expanding, we have approximately

$$\frac{P}{Q} = \frac{i^2\,\pi^2\,r^2}{l^2}\left(1 + \frac{i^2\,\pi^2\,r^2}{l^2}\right) E \qquad (8a),$$

after placing $l = 2\,a =$ length of column. On neglecting the second term in the parenthesis, as generally small compared with 1, we are conducted at once to formula (8).

Referring again to formula (7), and observing that $\frac{P}{e} = \frac{P}{E\,Q}$ is always very small compared with 1, we make no appreciable

error in neglecting it in the terms $\left(1-\frac{P}{e}\right)$, giving us for the square of the deflection at the middle of the column,

$$f^2=\frac{16\,e\,r^2}{P}\left[\frac{2\,a}{i\pi\,r}\sqrt{\frac{P}{e}}-1\right];$$

or, observing that $e=E\,Q$, and therefore $e\,r^2=E\,Q\,r^2=E\,I$, where I is the moment of inertia, about the neutral axis passing through the centre of gravity, of the cross section, we deduce

$$f^2=16\left(\frac{2\,a}{i\pi}\sqrt{\frac{E\,I}{P}}-\frac{E\,I}{P}\right) \qquad (9)$$

Now for values of P, greater than given by Euler's formula (8), which makes the term in the parenthesis in (9) zero, we note that as P increases, the parenthesis increases, since $\sqrt{\frac{E\,I}{P}}$ diminishes less rapidly than the term $\frac{E\,I}{P}$ for the same increase in P; therefore we conclude, as has been before stated, that *f, the deflection at the centre, increases with P for values above those given by* (8). This increase in f is so rapid for a small increase in P over that given by (8), that the breaking unit stress is soon exceeded as deflection proceeds ; so that if perfect elasticity was maintained up to the bending limit, we should expect Euler's formula (8) to give us very nearly the breaking weight, especially in the case of very long columns, where the unknown eccentricity in the position of P (especially in the case of columns with fixed ends) has not comparatively so great an influence as in the case of short columns; besides the theory is more nearly realized in the case of very long columns, where the bending can be quite appreciable before rupture begins or even the limit of elasticity is exceeded, though in the latter case, as we have seen, it requires but a small additional load to increase f considerably, and thus cause rupture with a load only slightly exceeding or approximately equal to that given by Euler's formula. This theoretical deduction is sustained by experiment as we shall see later, and it is plain that experiment alone can give us the limit of error made in any case. It is evident likewise that for columns of the ratio of length to diameter generally used, that the eccentricity in the load, etc., will generally

cause the crippling weight, as determined by experiment to be less than that deduced by aid of Euler's formula, which is found to be the case.

Euler's formula is not generally demonstrated in a very satisfactory manner. Thus, starting with the well-known equation,

$$E I \frac{d^2 y}{d x^2} = - P y$$

we easily deduce, in the usual manner,

$$y = f \sin \left(x \sqrt{\frac{P}{E I}} \right)$$

But since y must be zero for $x = 2 a$, it follows that $2 a \sqrt{\frac{P}{E I}}$ must be a multiple of the semi-circumference, so that if i is a whole number

$$2 a \sqrt{\frac{P}{E I}} = i \pi \therefore P = \frac{i^2 \pi^2}{4 a^2} E I.$$

Now it is a singular fact that the above value of y is not satisfied by any other values of P than those given by the last equation, unless f is zero, since no other value will give $y = o$ for $x = 2 a$; but for such values of P, we know from equation (9) above that f is zero, or that the so-called elastic curve reduces to a straight line; but the ordinary analysis leaves this important fact undetermined. In fact, it would seem from it that any value of P greater than the value given by the last equation was impossible, and would immediately cause rupture, since the value, $y = f \sin x \sqrt{\frac{P}{E I}}$ is no longer satisfied, for $y = o$, $x = 2 a$, since $2 a \sqrt{\frac{P}{E I}}$ is, by assumption, no longer a multiple of the semi-circumference; whereas, by equation (9) we can easily deduce the value of P corresponding to *any* assumed f.

By the ordinary analysis, therefore, we cannot assert, for values of P different from those given by Euler's formula, that the conditions of equilibrium are satisfied, or that the elastic curve is a *sinusoid;* in fact, for the one possible case, where P has just the value given by Euler's formula, the neutral line becomes a right line.

We see what an improvement Bresse's analysis is over the old, but even here the equation of the elastic curve is not found—only the expression for the middle ordinate is known.

The formulæ for columns "fixed at one end only," and "fixed at both ends," are easily derived from the preceding.

Thus for columns *fixed at one end and free at the other*, the elastic curve is the same as the part $A' D$ in the figure, and the deflection $C D$ is the same as in the first case.

If we make $i = 1$, and call the length of the column a, formulæ (7), (8) and (9) apply directly for the one case of bending represented by $A'\ D$ in the figure.

Similarly for columns *fixed at both ends*, so that the end tangents to the centre line coincide with the original axis of the column, we must conceive the column represented in the figure to be extended above A' and below B a distance $= A'\ D = D\ B$, with the same curvature as the part $A'\ D$, only concave to the right.

The deflection of this column at the centre, D, from the line of the end tangents, which are now parallel to $A\ B$, is $2\ .\ \overline{C\ D}$.

Hence if we call $2\ a$ the length and f' the centre deflection of the column fixed at the ends, we have only in (7), (8) and (9) to put (a) for $(2\ a)$ and $\frac{1}{2} f'$ for f to get the corresponding formulæ for the case of the column fixed at the ends. Therefore, we have for this case the deflection at the centre, when there are no repetitions of the simplest kind of elastic curve that can be supposed, from (7),

$$\frac{P f'^2}{e\ r^2 \left(1 - \frac{P}{e}\right)} = 64 \left[\frac{a}{\pi\ r}\sqrt{\frac{P}{e}\left(1 - \frac{P}{e}\right)} - 1\right];$$

or very nearly from (9),

$$f'^2 = 64 \left(\frac{a}{\pi\ r}\sqrt{\frac{E\ I}{P}} - \frac{E\ I}{P}\right);$$

and finally, in order that any bending be possible we must have

$$P > \left(\frac{\pi}{a}\right)^2 E\ I.$$

The condition that there shall be bending in the three cases, can then be expressed generally as follows:

$$P > \left(\frac{\pi}{c}\right)^2 E\ I;$$

where, if l is the length of column in each case, $c = 2\ l$ for column fixed at one end only; $c = l$ for column hinged or round at both ends, and $c = \frac{l}{2}$ for column fixed at both ends.

In the experimental formulæ of Mr. Johnson, given further on, Euler's formula for round ends is adopted, for that case, and the value of c in terms of l is determined by the experiments for the other cases.

Various attempts have been made, from time to time, to replace Euler's formulæ by other *rational* formulæ, but so far without success.

(*To be continued.*)

On RANSOME'S IMPROVEMENTS in the MANUFACTURE of PORTLAND CEMENT.*

By R. J. Friswell, F.I.C., F.C.S.

(*Concluded from vol. cxxiii, page 475.*)

The next question to be considered is the economy of fuel effected by the use of gas producers. Instead of consuming coke, these require only to be fed with slack, coal dust, or anything that will burn, fed in at intervals through a hopper. A two-cylinder works would require for its daily service probably one gas producer, capable of converting about six hundredweights of slack per hour into gas. In addition, there should be one similar producer in reserve kept going at only one-fifth of its full power, its gas being utilized under the boiler or drying floors; it would thus always be ready in case of a breakdown to take up its full production and supply the revolvers in motion. These producers are chambers of brick-work, in which a portion of the fuel burning gasifies the rest, a small jet of steam being blown in to assist the operation. They consume the whole of the coal, nothing escaping but ashes, and thus alone effect a great saving in the stoppage of the waste of cinders inevitable under ordinary circumstances. Numerous first-rate makers exist, and the use of gas producers is daily extending in the country, even in places where coal is raised either on or in close proximity to the works. Their value as economizers is recognized in all furnace operations requiring intense local heats. In steel and glass-melting industries employing heats like that of the cement kiln, it is asserted that, coupled with the use of regenerators, a saving of fifty to seventy per cent. of the fuel formerly used is effected. The only use for which their value is disputed is for steam raising, though in works where they are

* Reprinted from *The Engineer*, London, March 3, 1887.

required for other purposes, even here they would effect savings in fire-bars and in wages. Their cost is small, they occupy little room, they can be placed at any reasonable distance from the place where the gas is to be burnt, so as to be in close proximity to the coal siding, any laborer can shovel the slack into them, and they do not require constant skilled supervison. As we have before stated, there are several forms in use, that of Wilson being one of the best.

On the occasion of my inspection of Mr. Ransome's experimental furnace at Grays, Essex, the revolver was furnished with gas from a small producer, built by the works' bricklayer, which was gasifying about two hundredweights slack per hour; this not only supplied the furnace, but the valve was partly shut down to control the gas, which was, nevertheless, in excess of what was required. In fact, I felt convinced that the producer could have supplied two half-ton revolvers. There was accordingly here exhibited a consumption of about two hundredweights slack per ton of cement produced, instead of the usual seven to ten hundredweights coke per ton of cement clinker from the kiln. The results derived from this plan of gas firing are, therefore: (1.) Possibility of working with regenerative furnaces, thus saving all heat passing from the revolver. (2.) Use of about three hundredweights cheap slack per ton of cement instead of seven hundredweights coke. (3.) Complete combustion of all fuel, the steam injected being decomposed by the red-hot cinders, and producing carbonic oxide and hydrogen. In all ordinary furnaces great quantities of fuel are lost, in the shape of cinders inextricably mixed with the ash or mineral matter of the coal. (4.) The cement is kept entirely free from fuel ash.

In addition to these, the revolver gives us the following advantages: (1.) Economy of space, two revolvers with their appurtenances, and one in reserve, covering 900 square feet, turning out the same weight of cement as eleven kilns covering 4,400 feet. (2.) Continuous day and night working, and hence economy of fuel lost by necessary cooling, and subsequent re-heating of the kiln walls. (3.) Economy of repairs, which are simple and cheap. (4.) Less frequent need of repairs, as the continuous heat involves no racking like the alternate heating and cooling. (5.) Economy in first cost. (6.) Economy in grinding, a granular sand being pro-

duced instead of lumps of clinker, whereby crushers are quite abolished, and the wear and tear of the mill-stones greatly reduced. (7.) Economy of hand labor. Revolver cement can be handled on the American elevator system. (8.) Improved quality from (*a*) non-mixture with fuel ash; (*b*) no over-burning nor under-burning. (9.) Increased control over quality of cement, it being possible to stop, increase or diminish the flow of crushed slurry and to vary its quality at any time. (10.) Freedom from loss by accident. The ordinary kiln once charged and fired must burn out, whether charged wrongly or rightly, while, as before stated, any error in material can be rectified in a revolver as soon as discovered. (11.) Perfect control of temperature. And lastly (12) power of varying temperature according to nature of material. On the other side, there are the inherent defects of the kiln process, which need not here be recapitulated, having been fully treated already, and, moreover, being indicated by contrast in the above summary. It will have been noticed in the description that the time occupied by the crushed slurry in passing through the cylinder is about half an hour. Compared with the time occupied by the kiln process, this will seem to the practical cement-maker a very short—perhaps too short—a time to effect the necessary changes. It must, however, be remembered that a very great part of the kiln operation is taken up in warming the large lumps of dried slurry, which, like all earths, are very bad conductors of heat. This is not needed in the revolver, as the coarse powder almost directly attains the heat of the cylinder. The small size of the particles also permits the rapid liberation of the carbonic acid from the chalk, and after that is done it is not necessary to keep them heated, the necessary combination of the lime and clay taking place as soon as the particles are sufficiently hot, and this occurs long before the end of the cylinder is reached.

It must be remembered that a great part of the time taken in the kiln is necessary, by reason of its construction and the great mass of matter it contains, to the upper portions of which the fire can only reach after the lower parts have parted with most of their carbonic acid and moisture, which as they pass upward prevent the layers of coke above from burning. Much of the moisture also condenses in the upper part, only to be again driven out when the fire reaches it; this does not take place in the revolver, the

gases rushing quickly past to the regenerator and meeting only a moderate quantity of cold powder on its way in. It is also almost needless again to point out that at least one-seventh of the time is taken up in loading, another seventh in cooling, and a third, together nearly half, in unloading. Of the remainder it is to be observed that most of it is used in the gradual advance of the fire upwards, so that it may be safely stated that the lower layers of the kiln are sufficiently burnt a few hours after the start, and from then to the complete burning of the upper part they are simply lying idle. Could they be removed, as is the case in the revolver, they might at once be ground; but this removal is, from the nature of the method, impossible.

In addition to the method of burning just described, Mr. Ransome has introduced another improvement, which, however, is available only in certain districts. This is the introduction of a new material in cement-making in the form of blast-furnace slag. This is, as is well known, produced in enormous quantities, and notwithstanding innumerable attempts to utilize it, it is in truth a valueless waste material, costing the ironmaster large sums either for carriage to sea or for land to deposit it on. The ores used mostly for the production of iron consist of the carbonate of that metal mixed with silica and alumina. The latter are removed by the addition of lime, in the shape of limestone, to the furnace charge. The lime combines with the silica and alumina to form a fusible substance. This continually runs from the furnace and constitutes the slag in question. It contains the same elements as Portland cement, though in different proportions, as the following analyses will show:

Middlesborough Slags.			*Portland Cements.*		
Ferrous oxide, ... 0·72	3·64	0·61	3·41	5·46	Ferric oxide.
Manganous oxide, . . 0·35	1·02	trace	. .	. .	
Alumina, ... 24·69	20·70	22·28	6·92	8·00	Alumina.
Lime, ... 40·00	30·88	40·45	50·00	55·57	Lime.
Magnesia, ... 3·55	4·25	7·21	0·82	0·77	Magnesia.
Silica, ... 27·65	30·40	27·80	24·07	22·92	Silica.
Potash, ... 0·46	0·50	0·90	0·73	1·13	Potash.
Soda, ... 0·90	0·00	0·00	0·87	1·70	Soda.
Sulphur, ... 1·95	1·34	2·09	0·67	1·70	Sulphur.
Phosphorus, ... 9·25	0·00	0·00	. .	. .	

Neglecting the non-essential constituents, we have then a body containing silica in nearly the same proportion as does cement, lime in nearly two-thirds the proportion, and alumina in nearly a three-fold proportion.

If it be admitted that the functions of the alumina and silica in cement are reciprocal,* or nearly so, it follows that we may add these substances together, when we shall have the following results, again, for the sake of clearness, omitting the non-essential substances:

	Middlesborough Slag			*Portland Cements.*	
	1	2	3	1	2
Alumina and silica,	52·34	51·12	50·08	30·80	30·92
Lime,	46·00	36·88	40·45	59·90	55·67

From this it will be seen that in the slag the ratio of lime to the two other bodies is about 39 : 51, while in the cement it is 58 : 31. A simple calculation will show that on this basis the 39 + 51 = 90, or including the other bodies, 100 parts of slag requires the addition of 56 parts of lime = 100 parts of calcium carbonate, *i. e.*, dry chalk or limestone, to give a substance yielding a good cement. The only difficulty is the hardness of the slag, but this is overcome by Mr. C. Wood's method of running it into water, when it disintegrates, and yields a slag sand, which is easily ground with the chalk after separation of a little entangled

* On this point much has been written and many conflicting theories suggested (*Chem. News*, 1865, p. 152, etc.). Fremey has perhaps done the most practical work on the subject, when, as long ago as 1865, he prepared pure silicates and aluminates of calcium, and showed that the former alone had no hydraulicity, while the latter had that property when the ratio of alumina to lime lay between one and three molecules of lime to one of alumina; but he divided the setting process into two parts, in which he believed that both aluminates and silicates took part, the former by hydration, the latter by combination with hydrate of lime. Some years later (*Dingler's Polyt. Jour.*, vol. ccxv, pp. 538–552, and ccxvi, pp. 63–77) Erdmenger published a long and elaborate paper on the cause of hydraulicity in Portland cement. His results agreeing substantially with those arrived at by Fremey, led him to point out that the nearer a cement approaches to a two-fifth silicate the better. Two cements of this character he mentions as equally good. They had the following composition:

	Silica.	*Alumina and Oxide of Iron.*	*Lime.*
No. 1,	24·0	9·0	65·5
No. 2,	20·7	14·4	64·0

Thus showing considerable latitude in the relative proportions of alumina and silica. The three Middlesborough slags, if treated as suggested, would yield cements approximating to the following proportions:

	Silica.	*Alumina.*	*Lime.*
No. 1,	18	15	62
No. 2.	19	13	60
No. 3,	18	14	62

iron by sifting. Attempts have long since been made to produce this cement in the ordinary kiln, but have been abandoned, as the mixture has no coherence, and the lumps fell to pieces as soon as they got hot, and choked up the draught, putting the fire out.

This friability, disastrous in the kiln, is no defect but rather virtue in the revolver, so that in this matter the two inventions supplement each other, and the revolver thus brings a new cement material to the fore. It must, of course, be understood that slag cement cannot be made to compete with chalk-clay cement except in the neighborhood of iron works. In the South of England, the cost of carriage of the slag prevents it from being used, as clay is to be had on the spot. There is, however, every reason to believe that the slag cement may prove a profitable manufacture in the iron districts where the cement revolvers could themselves be fired by means of the blast furnace gases which are now everywhere being utilized as fuel.

Careful tests of the new material have been made, from which it would appear that slag cement attains its strength more rapidly than does ordinary Portland, for it was found that Ransome's had a breaking strain of 1,440 pounds, on an area of two and one-fourth square inches in twenty-eight days, while the Portland reached 1,325 pounds only in two years. The result is even more striking if short periods are taken, as the following shows:

Days.	*Portland 2¼ Square Inch Area, 123 lbs. per Bushel.* lb.	*Ransome's Slag Cement 2¼ Square Inch Area, 129 lbs. per Bushel.* lb.
2	510	740
3	698	870
7	818	1170

It is therefore evident that this process is well worth the attention of cement-makers in our iron districts, while the revolver process of burning must before long come into universal use.

NOTE ON THE DISCHARGE OF TURBINE WATER WHEELS.

By J. P. Frizell.

A note published by me in the Journal of the Franklin Institute for August, 1883, called attention to an error in the method of estimating centrifugal force used by writers on the turbine water wheel. My statement amounted to nothing more than this: The centrifugal force developed in a rotating body depends on the motion of the body itself, and not on the motion of that which sustains or environs it. Applied to the turbine, this simply asserts that the centrifugal force acting on the water, depends on the motion of the water and not directly on the motion of the wheel.

Certain criticisms by Prof. Church, of Cornell, N. Y., (see Journal of the Franklin Institute, for May, 1884,) led me to publish in this Journal (July, 1884,) a method of computing the discharge of turbines, embodying my view of the action of centrifugal force. This method, applied to certain experiments made by James B. Francis in 1851, (see Lowell Hydraulic Experiments), gives, with remarkable exactness, the results of twenty-four different experiments, in which the velocity is practically the only variable element. The ordinary theory represents these experiments with no approach to correctness.

In the May number of this Journal (current year), Prof. Church assails the formula used in these computations in an effort to show that it has no rational foundation. His criticisms are entitled to an answer, because he is, in one point, correct.

My expression for the centrifugal force in that article, is

$$\textit{centrifugal force} = M\,((\omega - \omega_1)^2\, r - v), \qquad (1)$$

in which M represents a mass of water so small that all its parts may be assumed to possess the same velocity. ω represents the angular velocity of the wheel, ω_1 that of the water with reference to the wheel, r the distance of M from the centre of rotation, v the radial velocity of the water.

To sum up the action of the centrifugal force upon the mass of water included between two floats of the wheel, I adopt a rough process of integration, founded upon measurements of the drawing

of the wheel and numerical computation, which avoids analytical difficulties, and leads to a substantially correct result.

Combining the expression so obtained with those deduced from other mechanical considerations, I find finally the following equation applicable to the wheel used in the experiments referred to.

$$1{\cdot}7277\ c^2 = 2\,g\,h + 5{\cdot}798\ \omega^2 - 1{\cdot}0844\ \omega\,c - 0{\cdot}5014\ c \quad (2)$$

in which c is the velocity of discharge from the guide openings.

Prof. Church points out that these formulæ are not homogeneous, and give contradictory and inconsistent results under different suppositions. In this he is correct. Nevertheless, in affirming that they have no rational foundation, he disregards one of the cardinal maxims of philosophy; concluding too hastily and on too narrow a basis of fact. The formulæ contain one error, too trifling to have any practical bearing, yet none the less objectionable to a mathematician. Otherwise they are thoroughly well founded in mechanical principles, as I understand the latter, and are, in no sense, empirical.

On re-examining the matter, I find that the term v, in the expression for centrifugal force, was introduced upon erroneous considerations. The effect of the error was so slight that it did not disclose itself. I cheerfully discard the offending member. The expression for centrifugal force then becomes

$$\textit{centrifugal force} = M\,(\omega - \omega_1)^2\,r \quad (3)$$

Remembering that $\omega - \omega^1$ is the angular velocity of the water, (3) is the ordinary expression for centrifugal force.

The correction, carried through to equation (2), simply cancels the last term in that equation and it becomes

$$1{\cdot}7277\ c^2 = 2\,g\,h + 5{\cdot}798\ \omega^2 - 1\,0844\ \omega\,c \quad (4)$$

This equation is free from the difficulties found by Prof. Church. The application of this formula to the experiments in question is exhibited in the following table:

Number of the Experiment in Mr. Francis's Series.	n — Number of Revolutions of the Wheel per Second.	$\omega = 2\pi n$ — Angular Velocity of the Wheel. Feet per Second.	h — Head acting on the Wheel. Feet.	Q — Discharge in Cubic Feet per Second.	
				By Experiment.	By Computation.
43	0·	0·	12·797	135 65	135·41
42	0·45431	2·8534	12·948	133·43	134·57
41	0·53232	3·3447	12·977	133·75	135·19
40	0·60000	3·7699	12·973	134·80	135·76
39	0·64702	4·0653	12·963	135·34	136·20
36	0·69471	4·3650	12·944	136·49	136·69
35	0·74211	4·6628	12·939	137·71	137·31
34	0·78401	4·9261	12·941	138·09	137·98
32	0·83624	5·2542	12·915	138·27	138·68
29	0·86643	5·4439	12·906	138·51	139·18
21	0·90201	5·6675	12·899	139·90	139·80
18	0·94507	5·9380	12·880	140·47	140·56
16	0·99345	6·2797	12·890	141·98	141·76
15	1·02373	6·4323	12·888	142·04	142·28
14	1·06744	6·7069	12 856	142·32	143·15
11	1·12518	7·0697	12·819	143·91	144·38
10	1·18460	7·4431	12·800	144·87	145·83
9	1·24514	7 8234	12·777	146·02	147 38
8	1·30933	8·2268	12·720	147·29	148·98
7	1·38249	8·6864	12·696	149·47	151·08
6	1·46149	9·1828	12·653	152·27	153·41
5	1·53218	9·6270	12·611	154·39	155·57
4	1·59651	10·0313	12·554	156·65	157·57
13	1·78404	11·2095	12·510	163 43	164·26

I have hoped for an opportunity of making a more extended application of this method, but the difficulty of obtaining the necessary data and the considerable labor involved, have thus far prevented. Only one occasion, in addition to the above, has presented itself for a test of the method. Mr. Hiram F. Mills, Engineer of the Essex Company, at Lawrence, Mass., has furnished me with a full size drawing of a Boyden turbine of eighty-four inches internal diameter, made by the Ames Company, of Chicopee, for the Washington Mills, at Lawrence, and tested as to discharge by Mr. Mills. The data for the complete verification of the computation cannot, of course, be exhibited as it would require the full size drawing to be published. Mr. Mills found the discharge under a head of twenty-nine feet and with a velocity of eighty revolutions per minute, 142 cubic feet per second. My method gives for the same conditions, 139·7 cubic feet per second.

Some other critical remarks of Prof. C. must be noticed. (1.) He says that I make the assumption "that if the sectional area of a guide passage (running full) is F and the '*velocity through F*' is $= c$, then the discharge through F is not $Q = F\,c$ but *five per cent. less.*" There is certainly a lack of conciseness in my article, on this point, but nothing of the contradiction he avers, and nothing that need occasion any difficulty to one familiar with the practical methods of hydraulics. c should have been defined not as the "velocity through F," but as the *velocity of discharge from F*, and similarly as to c_2. The velocity of discharge from an orifice is the velocity in the most contracted section, after passing the orifice. Practical hydraulicians would understand the matter correctly notwithstanding the definition, knowing that the velocity obtained by computation from the head or pressure acting on an orifice, is necessarily the velocity of the most contracted section of the issuing steam. I perceive, on reviewing my reasoning, that I did not rigorously observe the distinction between the orifice and the contraction section, but the contraction is so slight that this want of rigor can lead to no sensible error till we come to compute the discharge. Here we should make a material error if we multiplied the velocity in the contracted section by the area of the orifice. We must multiply the velocity in the contracted section by the area of the contracted section, which, in the present case, is five per cent. less than the area of the orifice.

(2.) Weisbach was one of the most skilful experimenters of his time, and one of the ablest writers, but liable to fall into a commonly received error like other people. I do not understand that my adoption of his coefficients of skin friction and efflux implies any concession as to the accuracy of his views on centrifugal force.

(3.) By the angular velocity of a rotating body, I understand the velocity of the point therein at units distance from the axis of rotation, and perceive nothing incongruous or out of place in expressing such velocities in feet per second.

[NOTE.—In the table on page 32 (J. F. I., July, 1884,) in the subcaption of column 8, instead of ω read $\omega\,c$.]

(4.) Prof. C. says that the burden of proof rests with me, I having first pronounced the ordinary theorem of centrifugal force in turbines, erroneous. This is very true, and the object of the present writing is to sustain that burden. Experiment is the court of last

resort in disputed physical questions, and I refer to the accompanying table for a comparison of my views with the results of experiment.

Nevertheless, I deem it no heavy task to maintain my position on purely theoretical grounds. The ordinary expression for the centrifugal force F, acting on a body A, of mass m, moving in a circular path of radius r, with a velocity v, is

$$F = m \frac{v^2}{r}$$

The question at issue, if a question can exist on such a matter, is: What does v mean? I affirm that it must mean the velocity of the body A, and that no correct use can be made of the formula if v is understood in any other sense. Weisbach and the other philosophers to whom I have referred in former articles, affirm that the formula will give correct results when v is understood, not as the velocity of A, but as the velocity of some other thing whose motion is not identical with that of A, and only connected therewith through some occult law of mechanics. It appears to me a waste of time to argue over such a proposition. It becomes a manifest absurdity as soon as stated.

My article of July, 1884, contained one error which has escaped Prof. Church's notice. I mention it to anticipate criticism. The wheel in question, like all turbines, had a certain amount of clearance between the fixed and revolving parts, through which some water issuing from the guide passages necessarily escaped without traversing the wheel. Of course, it is the aim of the wheel builder to make this clearance as small as possible, consistently with the proper movement of the wheel, but the loss from this source cannot be wholly avoided. In my reasonings, I assume the quantity of water traversing the guide and wheel passages as identical, and the result is theoretically, though I think not practically, affected by this slight error. Of course, the final computation of the quantity is free from direct error from this source, as it refers to the guide openings, and therefore includes all the water.

SCIENTIFIC NOTES AND COMMENTS.

ASTRONOMY AND PHYSICS.

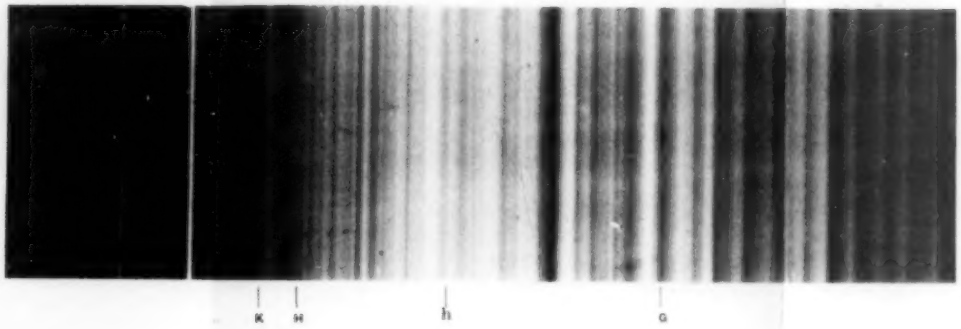
PHOTOGRAPHY OF STARS AND OF THEIR SPECTRA.—Prof. Edward C. Pickering, Director of the Harvard College Observatory, has kindly permitted the reproduction in this issue of the JOURNAL of several examples of his photographs of stellar spectra, which along with those illustrating his report on the Henry Draper Memorial, also appearing in this issue, will convey some indication of the great progress made in this direction during the last five years. As marking an important epoch in a research beset with difficulties, and yet promising results of supreme interest, these marvellous spectra deserve especial attention. The prints of the spectra are phototype reproductions of the original negative without correction.

Before more particularly remarking upon the photographs of stellar spectra, it seems proper, briefly here to refer the collateral work on the photography of the stars now being conducted at Harvard. In a paper, entitled "An Investigation in Stellar Photography," published some months since, and which is alike rich in theoretical considerations, and in description of important results attained, Prof. Pickering contributes the most valuable development of the subject now accessible. It covers the essentials in the whole range of celestial photography, and we limit ourselves to the selection of a few items of general interest.

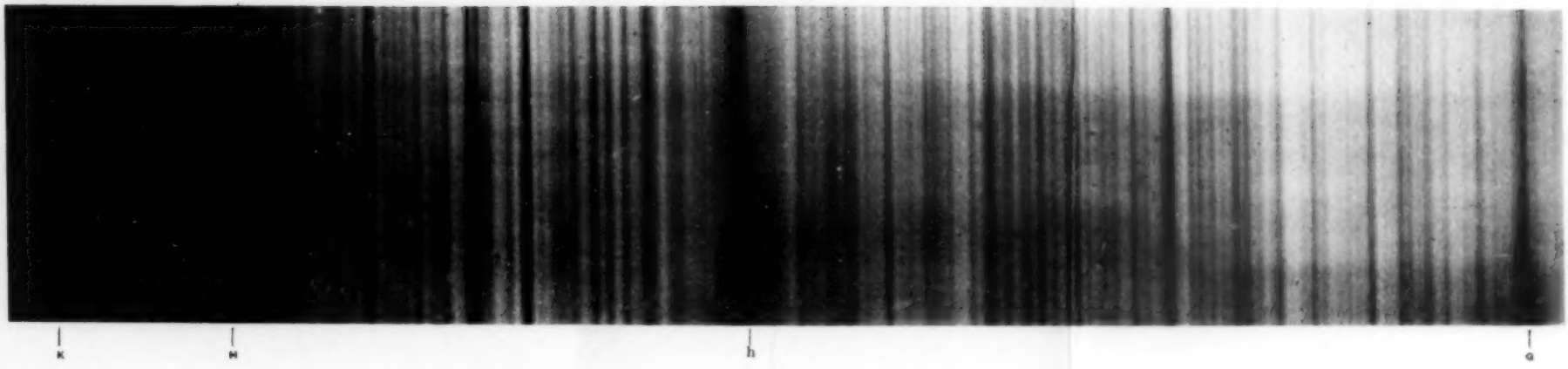
Stellar photography originated in an experiment made at the Harvard Observatory on July 17, 1850, when, under the direction of Prof. W. C. Bond, Mr. J. A. Whipple placed a sensitive daguerreotype plate in the focus of the fifteen inch equatorial, which, driven by the clock, was kept pointed upon the star *α Lyræ*. A satisfactory image of the star was obtained, but imperfections in the driving clock, and the lack of sensitiveness of the plates prevented further progress at the time. These difficulties were partially remedied in 1857, when Prof. G. P. Bond resumed the research, and gave the results to the scientific world in three remarkable papers, now ranking as classics, and presenting nearly all the arguments at present offered in favor of stellar photography. Passing by the extended investigations undertaken in 1864, by Mr. Rutherford, and continued so successfully through many years, we find Dr. Henry Draper, after the invention of dry plates, already in March, 1881, able to obtain a photograph of the nebula of *Orion*, upon which a star of the 14·7 magnitude is shown. A few years later, A. A. Common's fine photograph of the same nebula showed many stars not hitherto mapped, although it also omitted just as many previously catalogued. Photography was now equal to the eye. We find that in several important cases, it must now be declared superior in point of sensitiveness.

The first series of experiments, by Prof. Pickering, was undertaken in 1882, with a camera of but two inches aperture, and clearly demon-

HENRY DRAPER MEMORIAL.



O CETI. 1 PRISM.



α CANIS MINORIS. 4 PRISMS.

PHOTOTYPE J.BUTTERWORTH PHILADA.

strates the power of photography as a means of forming charts of large portions of the sky, and of determining the light and color of stars in all portions of the heavens.

A second series was undertaken in March, 1885, with results that have led to the adoption of a very extended scheme of stellar photography. The instrument employed was a Voigtländer lens of 8 inches aperture and 114·6 cm. focal length, so as to make the scale of the photographs as nearly as possible 2 cm. to 1°. The plates may cover as much as 12° in declination and 10° in right ascension. With the camera at rest, stars at the pole as faint as the fourteenth magnitude and at the equator as low as the eighth magnitude leave trails. Prof. Pickering has shrewdly applied these trails to stellar photometry, and has been able to determine the photographic brightness of stars with an average deviation of less than a tenth of a magnitude; a degree of accordance greater than that given by any other photographic method. When the camera mentioned is driven by clock-work and with an exposure of plates of an hour, charts may be constructed having the same scale and dimensions as those of Peters and Chacornac. Prof. Pickering has also applied photography to the transit instrument, and from careful measures shown that the position of a star may be determined from its trail with an average deviation of $0^s{\cdot}03$, which is about one-half the corresponding deviation of eye observations.

Reference to several photographs of special interest must not be omitted: The photographic discovery of a nebula around the star *Maia*, in the *Pleiades*, by the Henry Brothers, of Paris, is well-known. A photograph of the same group, by Pickering, several weeks previously, showed the peculiarity which, though recognized, was ascribed to a defect in the plate. As showing the value of a permanent record of the condition of the sky, we have the fact that the region containing Gore's new star, presently to be further spoken of, had been photographed at Harvard five weeks earlier than the star's discovery, and that its absence from the plate shows that it must then have been considerably fainter than when first seen.

The general character of the investigations of the photographic spectra of the stars, now being conducted as a memorial to Henry Draper appears from Prof. Pickering's report, here reproduced. We should, however, mention that one of the great advantages of this novel method of photographing stellar spectra comes to light in the case of an investigation of the spectra of the *Pleiades*, where uniformity of character is clearly shown, and the few stars not possessing these characteristics are pointed out as probably only in the same line of sight, and, therefore, in the study of the parallax of the *Pleiades*, specially to be observed. As many as 100 spectra are, by this process, photographed on a single plate. It would be impossible now to divine what may not result from such photography of the spectra of stars over the whole heavens, and from the review of the work at some future date.

The spectrum of *o Ceti*, shown in the accompanying phototype, belongs to the important class of bright line spectra, and deserves especial attention from the fact that Gore's new star, near χ^1 *Orionis*, strangely enough has a spectrum of similar type. It is well known that *o Ceti* is a long period vari-

able, and because Gore's *nova* steadily decreased in brightness from the sixth magnitude at its discovery, December 13, 1885, to less than the eleventh in May, 1886; it was classed as a variable of the same type. The similarity of the new star's spectrum, as photographed by Pickering, is, however, an additional confirmation.

The spectrum of *α Canis Minoris*, as shown, includes the portion between *G* and *K* is well suited to show the great power of the new method and of the extraordinary appliances employed. When Prof. Pickering is also able to include in the same photograph some well defined reference line, the determination of the motion of stars in the line of sight must become a comparatively easy problem. This most difficult kind of measurement of the displacement of lines in stellar spectrum will thus also have received a material improvement. M. B. S.

THE INTERNATIONAL ASTRONOMICAL CONGRESS.—Accounts (*Astron. Nach.* **116,** 384; *Nature*, **36,** 7, 54) of the Paris Conference on Stellar Photography (April 16–25, 1887) seem to show its decided success in attaining organization of the proposed work. There were present fifty nine astronomers and physicists, representing fifteen different nationalties.

The main object of this conference being the organization of a comprehensive plan for making a photographic survey of the heavens, the discussions, both in the astronomical and photographic sections, formed were almost entirely confined to the technical details of this great undertaking. With the desire that a great number of observatories should participate in the work, the conference selected instruments of moderate cost. Only refractors are to be employed; the aperture being 0·33 metre, the focal lengths about 3·43 metres, so that a minute of arc shall be represented approximately by 0·001 metre. It was decided that the photographic chart should extend to stars of the fourteenth magnitude, but that there should also be made supplementary negatives of shorter exposure, containing all stars down to the eleventh magnitude inclusive. The latter plates, on account of the sharper and more accurately measurable images, are to give the means for determining positions of stars to the eleventh magnitude with precision. All the plates to be used are to be prepared according to an identical formula, and the object-glasses of the instruments so corrected as to obtain the maximum sensibility of the photographic plates.

The conference adjourned after having delegated its powers to a Permanent Committee, consisting both of the Directors of the observatories, who may participate in the work, and of eleven members, to be elected. The following astronomers were chosen: Christie, Dunér, Gill, Prosper Henry, Janssen, Loewy, Pickering, Struve, Tacchini, Vogel and Weiss. As participants in the work, the following gave definitive adhesion before the election: Mouchez, Roget, Bailland, Trépied, Beuf and Cruls, a number of other members postponing the announcement of their participation to the near future. The Bureau of the Permanent Committee, with Mouchez as President and Gill, Loewy, Vogel as Secretaries, at a meeting April 27th, agreed to the following distribution of experimental work: (1.) Systems of cross

wires: Vogel. (2.) Photographic magnitudes: Struve and Pickering. (3.) Optical determination of images by means of photographs supplied by the Henry Brothers, Struve. (4.) The study of three or four stars nearly in a straight line, embracing the total angular distance of about 1°, and photographed necessarily at the centre, and at the corner of a plate: Paris, Algiers, Pulkowa and Leyden. (5.) Study of the deformations of films: Algiers, Meudon and Potsdam. (6.) Study of curved plates from the triple point of view of construction, means of covering with a film, and measures: Christie. (7.) Study of absolute orientation; that is to say, the mounting of the plates in the photographic telescope: The Cape and Paris. (8.) Study of the measuring instruments to be applied for the future utilization of the negatives: Postponed. (9.) The study of formulæ for preparation of plates in accordance with the general rules laid down by the Conference: Abney and Eder. (10.) Opinions of colors of stars on their photographic magnitudes: Dunér.

The institution of a series of test objects was also agreed to, and the preparation of a list of such objects assigned to Gill, Vogel and Henry. It is expected that the preliminary tests may be completed and the instruments constructed so as to be able to begin work by 1889. The congress also voted the appointment of a sub-committee, which should occupy itself with the application of photography to astronomy other than the construction of the maps, and desired that MM. Common and Janssen be charged to carry out the resolution. M. B. S.

THE MORRISON OBSERVATORY.—Prof. C. W. Prichett (*Publications of the Morrison Observatory*, Glasgow, Mo., **1,**) gives a description of the instrument of this observatory, the details of determination of the geographic co-ordinates and a valuable collection of miscellaneous observations. The principal instruments are an equatorial refractor by Clark, of 12¼ inches aperture and 17 feet focal length, and a transit circle by Troughten & Sims, with telescope of 6 inches aperture and a focal length of 77 inches. There are fitting accessories, and a fund, though somewhat meagre, for the support of the observations themselves. Among the observations here published are measures of 238 double stars occultations of glass and planets; two series of observations of the diameters of *Mars;* studies of the surface of *Jupiter* and the phenomena of its satellites; measurements on *Saturn*, and its system of rings and satellites; figure and dimension of *Uranus* and observations of comets. It is to be hoped that considering the excellent character of the work presented in this first volume, the wealthy west will soon endow the work of this observatory in such a manner as may allow the full capacity of the instruments to be developed. M. B. S.

NEW OPTICAL GLASS AND APOCHROMATIC LENSES.—Prof. E. Abbe (*Jena Ges. für Med. u. Nature*, 1886; *Journal, R. M.* **8,** 56) states some of the important results attained by himself and Dr. Schott, in the production of new kinds of glass for the use of opticians, and refers to some of the marked improvements he has thus been able to bring about in the microscope.

The researches have continued for five years, and have been supported by the Prussian Government with the final result of the establishment of the

Glastechnisches Laboratorium of Jena, where the new kinds of glass are manufactured for general use. Crown and flint glass can be produced, in which the dispersion in different parts of the spectrum is nearly proportional, so that in achromatic combinations it is now possible entirely, or almost entirely, to do away with the hitherto unavoidable secondary spectrum. Varieties of glass are produced with the mean index of refraction constant while considerable variations are given to the dispersion, or to the refracted index, while the dispersion remains constant. A high index of refraction may be retained with a low degree of dispersion.

The "apochromatic objectives" for microscopes with "compensating eye-pieces" are of the first applications. For photo-micrography these systems of lenses are specially commended. M. B. S.

ELECTRIC INDUCTION AND TRANSFORMERS FOR ELECTRICAL DISTRIBUTION.—At a recent meeting of the INSTITUTE, there was shown a small model of a secondary induction coil which had been used a few days previously in the INSTITUTE lecture course. It was intended to show, in a crude way, the general principle of induction of one current by another, and particularly the induction or generation of a current of great quantity but low pressure, by means of one of small quantity but great pressure, this being the system introduced some years ago in Europe and lately brought into this country.

The system is used chiefly for incandescent electric lighting at a distance. The currents required for such lighting being of great quantity and of low tension, the transportation of such currents, by means of wires from the generating station to the consumer, is accompanied either by a great loss of power in the mains, or else it necessitates great expense in the first cost of the mains, which, when considering the interest and depreciation, is equivalent to a running expense of no small amount. In a system of induction coils, or "transformers," as they are generally termed, the energy is transported in the form of a small current of very high tension, in which form it may be led great distances along a comparatively small conductor, without any great loss, as the size of the wire is to a certain extent proportional to the current, but independent of the pressure. Such currents, which would be useless in this form for incandescent lighting, are converted or transformed at the consumers by means of these induction coils, into currents of great quantity by low tension.

These transformers are in principle mere Rhumkorff coils reversed, the primary current being of high tension and small quantity, and the secondary the current of great quantity. In detail, the apparatus shown differed greatly from the Rhumkorff coil, which, in the usual form, would be very inefficient. It consisted of a coil eight and one-half inches mean diameter, of 127 turns of No. 16 B. & S. wire, weighing four pounds. The coil was taken just as it came off the reel, and bound with tape and shellaced canvas so as to have a circular cross-section. Next to this was placed a similar ring of very thick wire, consisting of eight turns of No. 3 B. & S. wire, weighing 3 pounds 5 ounces, the diameter of this ring being the same. These two coils were then bound together and wrapped with eleven and one-half pounds of fine, soft iron bell hanger's wire.

As the induction of currents in a neighboring wire takes place only with changes or reversals of the primary current, this primary current must either be intermittent or alternating. As the former is accompanied by destructive sparking, the latter is the only practical form of current to be used in practice.

When the apparatus was exhibited, an alternating current from a small Gerard machine was passed through a small german silver wire, No. 22, and into the fine wire coil. Upon connecting the coarse wire terminals with a similar german silver wire, it was instantly fused, showing that the same energy which passed through that fine wire in the form of a small current of high tension was transformed into one of such great quantity as to instantly fuse a similar wire. The same current was strong enough to fuse several strands of heavy iron wire, and to melt into a globule a three-inch wrought-iron nail.

Owing to the want of suitable measuring instruments, no quantitative tests could be made. As the only possible loss in such a coil is the heat developed in the copper wire due to its resistance, and the heat developed in the iron due to changes of magnetism and Foucault currents, it was quite correct to conclude that, as the coil kept quite cool, the efficiency was very high.

The generation of a current in such a coil may be readily explained on the same basis as the generation of currents in a dynamo. In the latter we know that when a wire passes through or "cuts," as it is termed, magnetic lines of force, a current will be generated in that wire. In the dynamos, the wire is moved mechanically nearer a magnet. In the transformer, as well as the Rhumkorff coil, it is the line of force or the magnetism which moves, as it might be called, across the wire. This may be understood as follows. Every current is encircled by numerous lines of magnetic force, as shown in the galvanometer and electro-magnet. These lines decrease in number as they are farther from the wire. A few years ago, the writer called attention to the fact that all the well-known laws of the mutual action and induction between currents could be explained by their lines of force. The attraction and repulsion of like and unlike currents could be explained by the attraction and repulsion of these invisible lines of force. The induction of a current in a wire, which was moved toward or away from a current, was explained by the cutting of the lines of force around the current by the moving wire. When a current is started in a wire, the lines of force, being proportioned in number to the current, will at first be very small circles around the wire, and as the current increases, these circles will grow larger; they may be said to be similar to the circular ripples produced on the surface of a still pond when a stone is thrown into the water. It is evident that a wire lying parallel to the first, and near to it, will be cut by these emanated lines of force, and, therefore, a current will be induced in it. From the laws of induction and of cutting lines of force, the direction of the induced current can be shown to be that actually observed. Similarly when the current was stopped, these lines of force came together again like a stretched rubber ring, and thereby cut the neighboring wires again, but in the opposite direction, thus inducing a current in the opposite direction. By thus considering the mutual action of currents as being merely the well-known action of the lines of force encircling the currents, the induction of currents in the Rhumkorff coil was readily explained

without the use of Ampère's laws of the mutual action of currents, or of Faraday's and Lenz's laws of induction.

The induction of currents in a transformer is, therefore, explained by the simple laws of cutting lines of force; when two or more wires lie parallel, and are encased in common by a sheathing of iron, the lines of force emanating from a primary wire when a current is started in it, cut the other wire, the secondary, in passing to the iron sheathing.

If the primary wire alone were encased by an iron sheathing, the lines of force from it would not pass outside of the iron casing; being retained by it, there would therefore be little or no induction in a secondary wire outside of the iron casing, even if quite near. This is made use of in some anti-induction wires, in which the wire which produces the induction is wound with iron tape or bands. This applies only to the primary or disturbing wire; a wire would not necessarily be protected from induction from others by being itself encased by iron; thus in the case of an electric light and a neighboring telephone wire, it is the former and not the latter which should be encased in an iron sheathing. C. H.

CHEMISTRY.

PHOTO-SALTS OF SILVER.—An exceedingly interesting account is given by M. Carey Lea in *Silliman's Journal*, of May and June, of a prolonged investigation of the haloid salts of silver and their relation to light, which may have an important bearing on the settlement of the question of the nature of the so-called latent image as well as of heliochromic possibilities, and at the same time furnish a more precise working basis for photographic operations. Without attempting a complete abstract, a few of the more salient features will serve to indicate the character and range of the investigation which the original of thirty pages alone can at all satisfactorily present. He describes in detail the formation by purely chemical means, without the aid of light, by a great variety of reactions, of haloid salts of silver, of great stability, when not exposed to the action of light, and exhibiting great variation of color, in the same haloid from rose to black. He proves the identity of these compounds with the products of the action of light upon the normal silver haloids by a series of reactions, including development, and reversing action in case of the iodide and bromide. He suggests the names photo-chloride, photo-iodide, and photo-bromide, to distinguish them from other haloids, since they were first obtained in an impure form by the action of light. According to his view, the so-called latent image as well as the visible products of the more prolonged action of light, are not sub-haloids of silver but rather a mixture, or a combination in non-stochiometrical proportions of a silver haloid with a small proportion of its sub-haloid; or possibly a mixture of the haloid with a small proportion of a stochiometrical compound of the haloid with its sub-salt. The general method for the formation of the photo-haloids is the same, but the photo-chloride is the most stable, and possesses the additional interest of a manifest tendency to the reproduction of colors, which renders it of great promise in heliochromy, obtainable thus in quantity and under

conditions more favorable to experiment than by previous methods. Among the variety of methods for producing it may be mentioned: chloriding of metallic silver; action on normal chloride by reducing agents; partial reduction of silver-oxide or carbonate by heat, and treatment with HCl; treatment of sub-oxide of silver with HCl, followed by nitric acid; action upon sub-chloride by nitric acid or an alkaline hypochlorite; action upon a soluble silver salt with ferrous, manganous, or chromous oxide, followed by HCl; reduction of an organic salt of silver, or of a soluble salt of silver by organic matter, and treatment with hydrochloric acid. C. F. H.

MANUFACTURE OF A YELLOW DYE-STUFF FROM GALLIC ACID. (From abstract in *Journal of Soc. of Chem. Indus.*, **6.**, *285*).—The dye, which can be fixed on the mordanted fibre, like alizarin, and which has been termed "galloflavin," is obtained by the action of the air—*i. e.*, oxygen—on alkaline solutions of gallic acid. The process of oxidation depends on the amount of alkali present, for, whereas, it proceeds too quickly if the alkali be used in excess, the oxidation can be moderated by diminishing the quantity of alkali.

In practice, five parts of gallic acid are dissolved in eighty parts of alcohol of 96° Tr., and 100 parts of water. The cooled solution is gradually mixed with seventeen parts of a potassium hydrate solution of 30° B., stirring all the while, and never allowing the temperature to rise above 10° C. It is then exposed to the action of oxygen, either by blowing air through it or agitating it briskly.

The progress of the oxidation shows itself by the liquor assuming at first an olive-green or greenish-brown color, until finally a crystalline precipitate separates out. When the amount of this precipitate no longer increases, the operation is finished. The mass of crystals is quickly filtered, dissolved in warm water, decomposed with hydrochloric or sulphuric acid, and boiled, when the dye is precipited in the state of glittering greenish-yellow plates. These are washed, and can then be applied for dyeing or printing. Galloflavin dyes cotton, mordanted with alumina, greenish-yellow, which turns into a very brilliant yellow by the treatment with tin crystals. The chromium-lake of galloflavin is distinguished by being especially proof against soap, air or light. H. T.

IMPROVED PROCESS FOR MANUFACTURING TANNIC ACIDS IN CRYSTALS OR GRAINS. (Dr. H. Byk. *English Patent*, 15,436).—The patentee prepares a granulated tannic acid by dissolving it in a suitable solvent, and adding five per cent. alcohol containing 0·05 per cent. glycerin. This solution is concentrated and spread to dry on sheets of zinc or other metal, from which it can then be detached in semi-transparent grains. The glycerin may be replaced by gum or carbohydrates. H. T.

THE REDUCTION OF NITROBENZOL BY ALCOHOL UNDER THE INFLUENCE OF SUNLIGHT. Ciamician and Silber (*Gazz. Chim. Ital.*, **16**, 536).—An alcoholic solution of nitrobenzol exposed to direct sunlight for some months, becomes brown, and acquires an acid reaction. It then contains aldehyde, a substance that responds to the reactions of aniline, and exceedingly small quantities of another base, which appears to be quinoline. W. H. G.